VOL. 14 NO. 2 APRIL, 1957

BRITISH JOURNAL OF INDUSTRIAL MEDICINE

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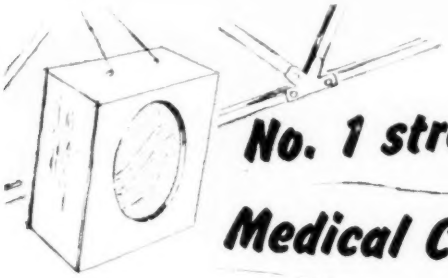

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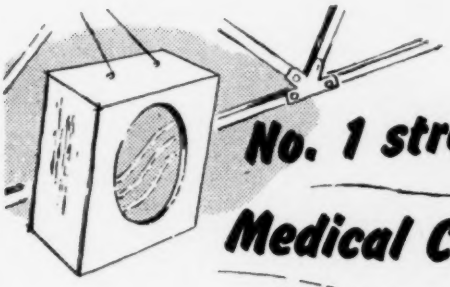

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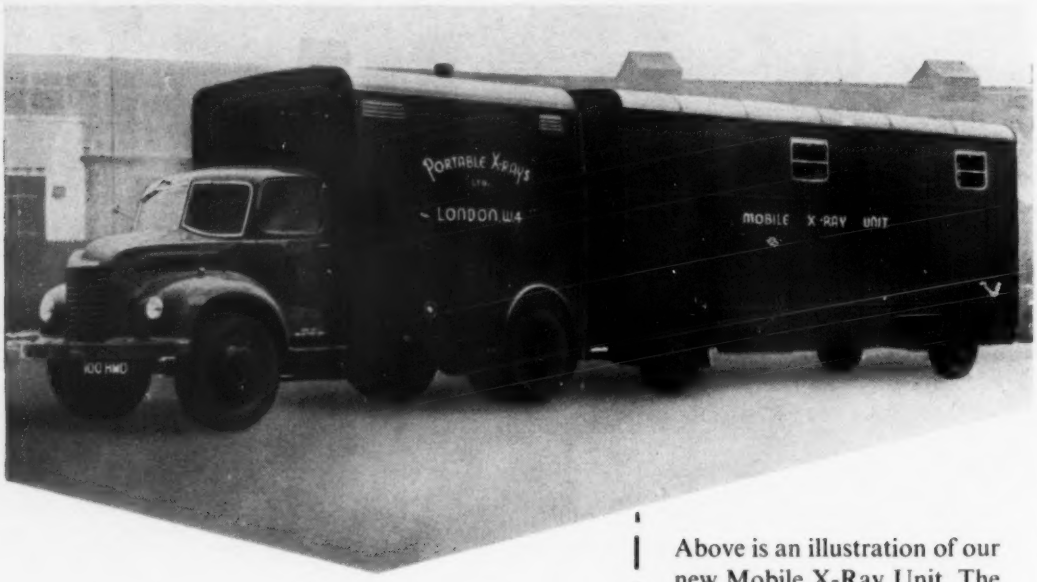

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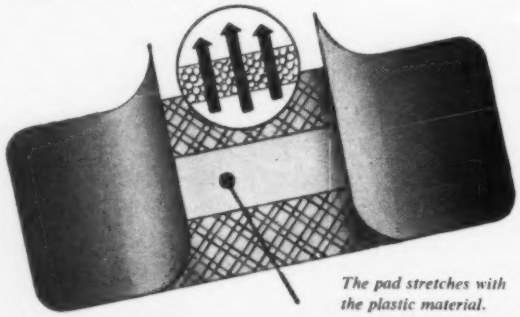

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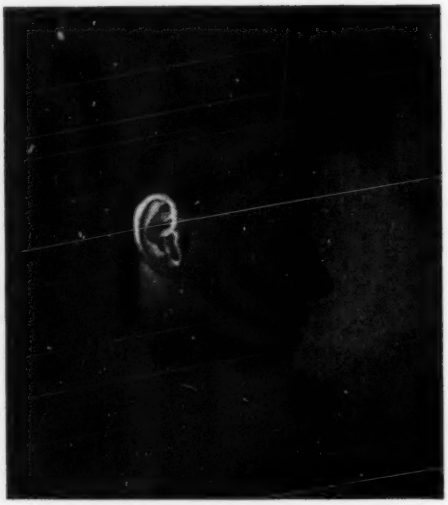

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THE HEALTH OF THE WORKER*

BY

P. A. B. RAFFLE

From the Medical Department, London Transport Executive

The health of the worker must nowadays be considered against a background of improved social conditions, of death rates which have fallen continuously for a century, and of a reduction in communicable diseases.

At one time industrial medicine was preoccupied with the direct and demonstrably harmful effects of certain occupations on health (Schilling, 1956). Now that many of these situations have been brought under control, it can be concerned with the many physical and psychological factors of work which may influence health.

Lord Horder (1956) wrote:

> "The relations between health and industry may be thought of in terms of a two-way track. Advances in the science and art of medicine can be of great service to industry if properly applied, and industry can make very useful contributions to medicine by studying the environmental conditions of large groups of workers and the influence of these conditions upon the health of the individual."

This is a concept which would have appealed to Sir Edwin Chadwick, that great pioneer, who used all methods and materials in his fight to improve the health of the community.

THE CONTRIBUTION OF MEDICINE TO INDUSTRY

It is accepted that a healthy working community is happier and more productive than a less healthy one. Yet only the haziest ideas exist of what is meant by health. The World Health Organization (1948) produced the somewhat ponderous definition, which has not yet been bettered, that "health is a state of complete physical, mental, and social well-being and not merely the absence of disease or infirmity". Health as thus defined cannot be measured. But the absence of health, *i.e.*, sickness, can be studied clinically and absence from work due to sickness can be measured statistically.

The Use of Sickness-absence Statistics

In the study of health, it is necessary to supplement clinical impressions by measuring and comparing the amount of sickness among large groups of workers and so discovering whether different occupations produce different patterns of disease. One method is to study the rates of absence from work attributed to sickness. Reflected in these rates are not only illnesses, but also the reactions of people to their working environment, to the morale of the group in which they work, and to their social adjustment inside and outside the factory.

Among the many factors affecting absence from work attributed to sickness are the nature of the work, the degree of physical fitness required in order to undertake it, the environmental working conditions, the quality of supervision, the regulations concerning National Insurance benefits, the provision of sick pay, and all the effects on the individual of his social life outside the factory. As one direction of the two-way track, industry expects help from its doctors in unravelling these factors and in drawing attention to those which management can alter.

With so many possible factors to consider, it is not surprising that progress in this work has been slow. Because there was no information on the sickness-absence experience of the general population which could be used as a base-line for comparing occupational groups, industry had to construct its own base-line by collecting the information about large groups of employees for a number of years. An example of this is the recent publication of *Health in Industry* (London Transport Executive, 1956), a book which gives sickness-absence data for large groups of London Transport staff.

Variables Affecting Sickness-absence Rates.—There are three well-known but important variables which must be taken into account when comparing the sickness-absence rates of groups: age, whether the absence is short and uncertificated or long and supported by a medical certificate, and sex.

Age.—The graph of the annual average duration

* A public lecture delivered under the auspices of the Chadwick Trustees, on November 22, 1956, and published with the approval of the Trustees.

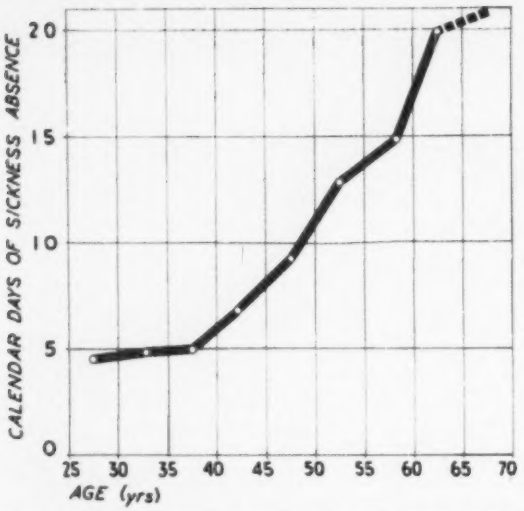

FIG. 1.—London Transport Executive central bus drivers 1949-52: average annual duration of absence per person from all causes (absences of four to 182 days' duration).

The average annual duration of sickness absence = the average number of calendar days of sickness per person per year.

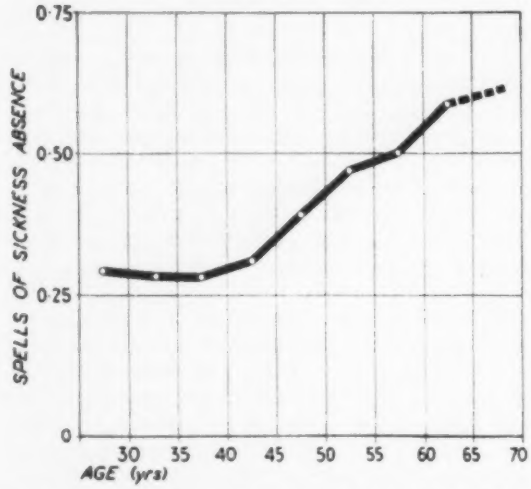

FIG. 2.—London Transport Executive central bus drivers 1949-52: annual inception rate (spells) of absence from all causes (absences of four to 182 days' duration).

The annual inception rate (spells) = the average number of spells of sickness absence beginning per person per year.

of absence attributed to sickness for London Transport bus drivers is a typical example (Fig. 1) of the effect of age. The rate stays fairly constant at just under five calendar days per man per year up to the age-group 35-40, then rises steeply until at the age of 60-65 the rate reaches four times this figure.*

* Absences lasting more than six months are curtailed at 182 days' duration (London Transport Executive, 1956).

The annual inception rate (Fig. 2), that is, the average number of spells of sickness per man per year, shows that the increase is about twofold over the same age range. The older men take about twice as long to recover from each of their illnesses as the younger men, the average length of absence per spell rising from 15 calendar days at the ages of 25-29 to 33 days at 60-64. This general pattern is seen in most of the groups of men studied, though there may be variations in the steepness of the slope. The same pattern is also common in individual diseases or groups of diseases, though there are some exceptions, notably in infectious conditions which tend to give higher rates at the younger ages. Thus any statistics which do not take into account the age structure of the group being studied can give very misleading results.

Short-term Absences.—When short-term, uncertificated absence attributed to sickness is studied, an entirely different picture is seen. Short-term absence is conveniently defined as absences of one, two or three days' duration. The graph of the average number of spells of this duration per year in London Transport drivers (Fig. 3) shows that the rate at the younger ages is nearly twice that of the older men. There may be at least three influences at work here. First, these short-term absence rates may be an index of morale and stability in a group. An older driver with more domestic responsibilities than a younger man is perhaps less likely to take

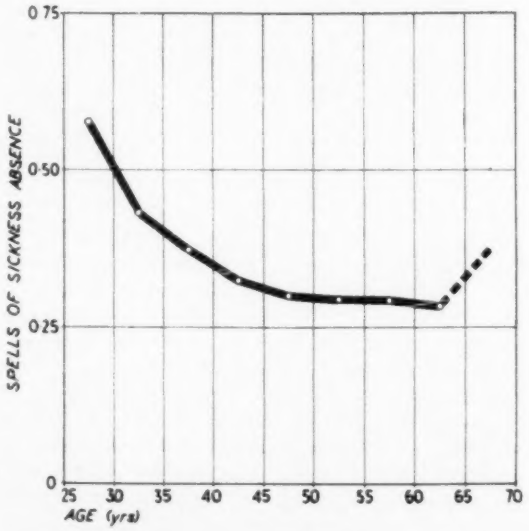

FIG. 3.—London Transport Executive central bus drivers 1949-52: annual inception rate (spells) of absence from all causes (absences of one to three days' duration).

The annual inception rate (spells) = the average number of spells of sickness absence beginning per person per year.

single days off, even when he is not feeling well. Second, as younger men recover from sickness more quickly than older men, they will tend to have more sickness spells of short than of long duration. Third, the common cold, a frequent cause of short-term absence, probably contributes to the higher rate of the younger men. Young people may not have as much immunity to colds as older people because they have not had the opportunity to be infected by so many different strains of virus. In still older age groups more complications of the common cold, especially bronchitis, can be expected, and therefore long absences are more likely than short ones. Some support is given to this view when the figures for long-term absences due to colds and influenza are studied. The rates tend to be high at the younger ages, fall in the middle years, and rise again at the older ages. And it is also of interest to note that the seasonal variations of short-term absences follow closely the seasonal variations of long-term absences attributed to respiratory diseases and to all causes.

Sex.—The sickness-absence rates for women differ markedly from those for men. The tendency is for the average number of spells per woman per year to remain fairly constant throughout working life, or even to fall slightly at the older ages. The average number of days of absence per woman per year rises with increasing age, but not to the same extent as with men. Thus the younger women experience a larger number of absences of shorter duration than the younger men. This difference is not accounted for by the diseases peculiar to women.

Women as a whole have higher rates of absence attributed to sickness than men and there is also considerable difference depending on their civil state.* A convenient method of comparing the sickness-absence experience of two occupational groups is to compare the actual recorded sickness-absence of the first group with what that group would be " expected " to have if it had the experience of the second group, making due allowance for the age-distributions of the two groups; the results are expressed as a percentage of the figures " expected " (London Transport Executive, 1956). Table I shows (in round figures) the comparison, by this method, of the experience of single and married women clerical staff with that of male clerical staff. Single women have more absence than men (for instance, they have 65% more short-term absences than would be expected at the men's rates) and married women have more absence than single women (London Transport Executive, 1956). As a rough guide, for clerical staff long-term absences attributed to sickness in men, single women, and married women occur in the ratio 1 : 1¾ : 2.

TABLE I

SICKNESS-ABSENCE RATES 1950-52 FOR ALL CAUSES IN LONDON TRANSPORT WOMEN CLERICAL STAFF*

	1—3-Day Absences	4—182-Day Absences	
	Spells per Annum (%)	Spells per Annum (%)	Days per Annum (%)
Single women	165	170	180
Married women	210	200	225

* Actual figures compared with " expected " figures based on experience of male clerical and technical staff.

When bus conductors are considered, single women have twice the sickness-absence rates of the men and married women three times the men's rates.

Further Factors Affecting Sickness-absence Rates.—It follows that before any valid conclusions can be drawn from comparing sickness-absence experience between groups, at least their age structure, the proportion of long and short absences and the proportion of men, single and married women, must be known. Even then other precautions must be taken, such as to study large groups so that chance variations do not play too important a part in the overall pattern; to avoid basing deductions on one year's experience (this can be full of pitfalls because there are years when epidemics of colds and influenza have a marked but varying effect on the experience of different groups; when several years' figures are added together a much more reliable picture of the groups is given); and to know what factors are affecting the selection of the persons in the group, their recruitment into the group, their continuance as a member of the group (which is in itself a form of selection), and their reasons for leaving the group, be it promotion, voluntary resignation, age retirement, employer's opinion on ability, or physical fitness for the work.

The Accuracy of Diagnoses Related to the Validity of Sickness-absence Statistics

Some people question the value of sickness-absence statistics on the grounds that the diagnoses on the medical certificates from which the statistics are built up vary greatly in their accuracy and precision. This view ignores the basis of the use of these statistics, which is the comparison of the experience between occupational groups to discover whether different occupations produce different disease patterns. The precision and accuracy of the diagnoses recorded for one occupational group

* Civil state can mean no more than whether they call themselves " Miss " or "Mrs.". It is unlikely that the employer has more detailed information than this about their personal lives and home responsibilities; for instance, a " married " woman may be widowed, divorced, or separated.

should not differ sufficiently from those recorded for another occupational group to invalidate the comparison between the groups. The presence or absence of a difference in sickness-absence experience between occupational groups demonstrates whether or not there is a health problem in one of them which should be investigated by one or more of many other methods of enquiry.

The Value of Sickness-absence Statistics

Determining Frequency of Hernia.—A simple example of the value of sickness-absence rates is that they answer questions about the frequency of hernia in bus drivers. "Straining at the wheel" was a commonly heard phrase and the implication was that the drivers suffered unduly from ruptures. This is a diagnosis which could be expected to be recorded precisely. The clinical impression among the doctors working in London Transport was that the rate among drivers was not unduly high compared with the general population, and that this was to be expected because the inguinal canals would be protected by the flexed thighs when driving. Although drivers have, age for age, 82% of the average number of spells of sickness-absence per person per year that conductors have for all causes, they only have 60% of the conductors' experience for hernia (London Transport Executive, 1956). There do not seem to be any fallacies in comparing these two groups of men who differ only in the work they do except—to be mentioned later—that men of different physique may select themselves for the two jobs and different physiques may predispose to different chances of developing a hernia. However, the point was made that drivers' experience of this condition was more favourable than had been thought.

Evaluating Relationship between Responsibility and Sickness.—The relationship between responsibility and exacting duties and sickness is attracting attention to-day. It is a difficult subject to study because the number in responsible positions is comparatively small and there is a large element of selection involved; only certain types of men reach the higher grade posts. In London Transport garages there are officials who correspond to the departmental managers in other organizations. They are responsible for the staffing of all the buses which run from their garage and they have to deal with the administration and discipline for any number between 300 and 1,200 men and women. They certainly can be considered to carry heavy responsibility. They are mainly ex-drivers and conductors who have been gradually promoted to their present positions. Their sickness-absence experience is interesting

TABLE 2

SICKNESS-ABSENCE 1952-54 FOR ALL CAUSES IN LONDON TRANSPORT GARAGE OFFICIALS*

Garage Officials Compared with	1—3-Day Absences	4—182-Day Absences		
	Spells per Annum (%)	Spells per Annum (%)	Days per Annum (%)	Days per Spell (%)
Bus drivers	50	80	100	125
Male clerical and technical staff	20	90	125	140

* Actual figures compared with "expected" figures based on the experience of bus drivers and of male clerical and technical staff.

(Table 2). When their experience age by age is compared with that of drivers, from which grade many were promoted, they are found to have less short-term absence; of long-term absence they have fewer spells and the same average number of days per person per year and more average length of absence per spell. When these officials are compared with male clerical and technical staff, who have broadly the same sick pay and leave entitlements, they are found to have even fewer one- to three-day absences, and of long-term absences about the same number of spells, a higher annual average duration and average length of absence per spell. Though the figures on which these results are based are small, they suggest a picture of a group of men who have been selected because of their ability, loyalty, and hard work and who work on during the minor illnesses for which other men would take time off and who, when they do have an illness, take longer to recover, like a fly-wheel which is hard to stop and equally hard to start up again. This is obviously a group of men which an industrial medical service should watch, especially now that the figures have supported the clinical impression which initiated the investigation.

Checking Level of Sickness-absence in an Office.—Another example of the use of sickness-absence statistics to ascertain the facts of the situation occurred when a question was asked whether the amount of sickness among the girls in a typing pool was abnormally high. Arguing from first principles, it would not be surprising if the rates in a large typing pool were higher than in the remainder of women clerks, because environmental conditions in large offices are usually less satisfactory than those in small offices. For example, ventilation without draughts is more difficult to arrange; adequate heating for all without overheating those at the periphery of the office is difficult to provide; dependence on artificial lighting rather than daylight for a large percentage of the staff is more common; and noise and the visual disturbance of

many people moving around are more noticeable in large offices than in small. Infectious diseases may be transmitted more widely among people working in large workshops or offices than among the same number of people working in a number of small offices or shops.

With all these factors weighing in favour of an above-average sickness-absence experience in the typing pool, the fact was that, during the three years 1950-52, the typists' rates, for spells and for durations, for short and for long absences, did not differ by more than 2% from those "expected" on the basis of the generality of women clerks. To show that these girls were having the same sickness-absence rates as were expected from their age and marital status was a negative finding of value, because any apprehension felt by the girls or by management was thereby allayed.

THE CONTRIBUTION OF INDUSTRY TO MEDICINE

There are probably three conditions which are exercising the minds of those responsible for preventing ill-health in the community more than any others—bronchitis, coronary heart disease and cancer of the lung.

The Study of Bronchitis

The study of bronchitis is a subject in which industry can help a great deal, and information from this source is beginning to accumulate (Roberts and Reid, 1954; Gregory, 1955; Reid, 1956). Industry can provide figures to compare the bronchitis experience of large groups of people in different occupations; certain ideas of the causation and natural history of the disease can be developed from these data. It is a complex problem, not least because of the difficulty of defining what is meant by "bronchitis" and because of the number of factors which may influence this condition. For instance, why do bus conductors experience, age for age, 130% of the annual average days of absence and 145% of the average number of spells of absence that bus drivers have from "bronchitis"? Is it because a conductor is more disabled by a mild attack from running up and down the stairs than the driver is from driving the bus, and therefore is less likely to come to work? Or is it because conductors have 130% of the long-term absences from colds and influenza that drivers have, and, because the rate is particularly high at the younger ages (150% or more), the respiratory system of conductors is more damaged by these infections and made more liable to attacks of bronchitis in later years? Or is it because drivers and conductors are different types of people in any case? It has recently been shown that they differ in at least one aspect of physique. These are some of the questions that those interested in preventive medicine must answer before it is possible to formulate methods of preventing a disease which accounts for 11% of the total sickness-absence of many groups of workers (London Transport Executive, 1956).

Coronary Heart Disease

Morris and Raffle (1954) and Morris, Heady, Raffle, Roberts, and Parks (1953) showed that bus drivers had more coronary heart disease than bus conductors and what they had was more severe. Thus the mortality rate, age for age, for drivers in the first three days, first three months, and first three years, after the first clinical episode of coronary ischaemic heart disease, was twice that of male conductors. Drivers and conductors are similar groups of men in most respects; they live in the same areas, generally near their garages, their wage is much the same, and they come from the same group of the community. Where they differ is in the work which they do. One of the respects in which their work differs is in the amount of physical activity in driving a bus and conducting it. This led Morris *et al.* (1953) to study other occupations and a similar relationship was found. Men whose work involved physical activity had a better experience from coronary heart disease than those whose work was more sedentary.

Lack of physical activity is one of many factors possibly concerned in the aetiology of coronary heart disease. Others include the amount and type of fat in the diet, the amount smoked, the race and the social class from which the person is drawn, and the amount of responsibility accepted. One further factor which has been observed to affect the incidence of coronary thrombosis is constitution as reflected in body shape (Gertler and White, 1954). Morris, Heady, and Raffle (1956) therefore compared the sizes of uniform of a sample of London Transport bus drivers with those of male conductors. It was immediately apparent (Fig. 4) that at all ages—even at 25-29 before occupation could have caused the difference—bus drivers measured more round the waist than conductors, after due allowance had been made for height. When chest measurements were compared, the same feature was found. It was also shown (in a much smaller sample) that those drivers who had joined London Transport as conductors and had been promoted to drivers after training and those who had joined as drivers and therefore had previous driving experience, were both bigger than conductors, even at the youngest ages.

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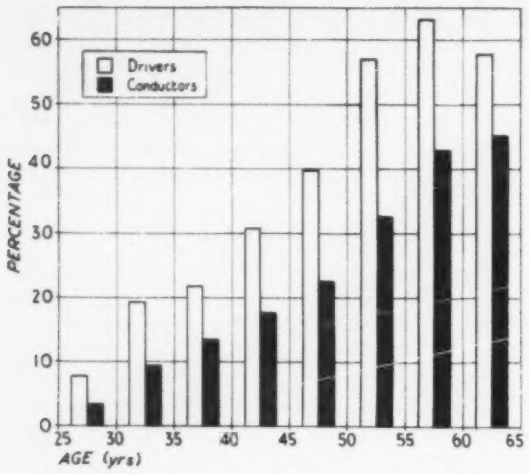

FIG. 4.—Comparison of London Transport Executive drivers and male conductors, 1954: percentages of sizes of uniform greater than 36 in. waist measurement (adjusted to take height into account).

of drivers and conductors and their different experience of coronary heart disease. It has, however, been clearly shown that industry can provide data for medical research which are not available from other sources. It has also been shown that self-selection or selection by the operation of other factors can vary the composition of groups of workers to an extent which cannot be predicted. One of the questions immediately posed is: "Is the difference in physique between drivers and conductors related to the difference in the psychology between them which makes one group wish to drive and the other to conduct?" The demonstration of such a relationship would be of fundamental value to medical research.

Cancer of the Lung

The increase in the incidence of cancer of the lung in the population has had considerable publicity, especially since two probable causes of the increase have been demonstrated. Work in this country and elsewhere has shown beyond reasonable doubt that there is a relationship between cancer of the lung and heavy cigarette smoking. There is also some ingredient in the air of towns which predisposes to the development of the condition. The urban death rates from cancer of the lung are consistently higher than the rural rates, and Stocks and Campbell (1955) showed that this still applies when allowance is made for differences in smoking habits.

One of the constituents of the air of towns which has been suggested as being responsible is the exhaust gases from diesel engines. Kotin, Falk, and Thomas (1954) demonstrated that the exhaust gases of petrol engines contain 3:4-benzpyrene and other polycylic hydrocarbons which are known to produce cancer when painted on the skin of mice. Later work by Kotin *et al.* (1955) indicated that bench-run diesel engines only produced 3:4-benzpyrene when badly maintained or adjusted.

In view of its importance to the health of urban dwellers, this problem was investigated from two aspects. The chemical composition of the exhaust products of the diesel engines of moving buses was investigated and a study made of the incidence of cancer of the lung among various groups of London Transport staff.

Commins, Waller, and Lawther (1956) in an interim report showed that, although the concentration of smoke was greatly increased during periods of intense vehicle activity in a diesel bus garage, there was no increase in the concentration of 3:4-benzpyrene, which remained very similar to that of the outside air. They also showed, by direct estimation, that the exhaust products of diesel buses contain no 3:4-benzpyrene when the engines are in average condition and very little, if any, when they exhibit some abnormality.

During the course of this investigation, a preliminary study of the lung cancer rates among London Transport staff was undertaken. The numbers of cases were very small and the deductions, therefore, can only be tentative. It was decided to include not only deaths, but also retirements from the service and transfers to alternative work on account of ill-health, due to lung cancer. The inclusion of retirements and transfers may weight the figures unfavourably in comparison with the national death rates by including recovered cases, but the exclusion of such cases would have made the figures artificially favourable by ignoring cases dying after leaving the service, or after transfer to other work.

It was assumed that engineering staff working in bus garages had a greater exposure to exhaust gases than any other group of staff, and that, if any carcinogen be present in the gases, their experience of cancer of the lung would be worse than that of the general population and worse than that of other men in London Transport.

Table 3 gives the crude rates for deaths, retirements due to ill health, and transfers to alternative work for various groups of men aged 45-64 during the years 1950-54. In Table 3 the groups of staff are arranged in the order of increasing exposure to exhaust fumes (based on general observation and not chemical estimation). Though the rates are not corrected for age within the age range 45-64, as has been done with the other figures so far presented,

TABLE 3

DEATHS, ILL-HEALTH RETIREMENTS, AND TRANSFERS TO ALTERNATIVE WORK DUE TO LUNG CANCER IN LONDON TRANSPORT MALE STAFF AGED 45-64

Group of Staff	Exposed to Risk (man years)	Deaths, Ill-Health Retirements and Transfers to Alternative Work 1950-54	
		Number	Annual Rate per 1,000
Motormen and guards (L.T. railways)	8,253	11 (10)†	1·3
Engineering staff (trolleybus depots)	5,529	10 (9)	1·8
Engineering staff (Chiswick Works)	9,979	12 (12)	1·2
Central bus drivers	33,466	23 (17)	0·7
Central bus conductors	16,978	18 (15)	1·1
Engineering staff (bus garages)	18,140	22 (21)	1·2
	Male Population* Aged 45-64	Deaths 1950-53	
England and Wales	19,947,000	26,689	1·3
Greater London	3,834,000	6,292	1·6

* Obtained by adding the populations given in the Registrar-General's statistical reviews for the years 1950-53 inclusive.
† Deaths in brackets.

it can be said that, in each group of staff, the proportion of men in each of the age groups, 45-54 and 55-64, were the same as in the general population of England and Wales, except that in both the bus and trolleybus engineering staff there was a higher percentage in the older age group. This should have made their experience even more unfavourable, because the incidence of the disease in the general population increases with age, at least until the age of 65.

Even though the figures are small, the rates do not differ greatly from the death rates in England and Wales and in Greater London; in fact, with one exception, they are lower than the experience of the general population. There is certainly nothing resembling the twelve-fold difference between non-smokers and smokers which Doll and Bradford Hill (1956) report. No excess is shown in the bus engineering staff, where an excess would have been expected if diesel exhaust fumes contained a carcinogen which was active on human lungs.

The figure for the trolleybus engineering staff is the highest, although this group of staff is less exposed to exhaust fumes than any except the railwaymen. Stocks (1952) found that the cancer of the lung death rates were highest in the boroughs in the east of London. He demonstrated that there was a close correlation between this death rate and the density of population, but that the prevailing wind from the south-west also had an effect. A high proportion of the trolleybus depots are in the north-east of London, and it seemed possible that this might explain the high figure for the trolleybus engineering staff.

It was, therefore, decided to combine the figures for the bus and trolleybus engineering staff, to distribute the deaths between the four segments of London according to the place of work (which is also very similar to the residential area), and to compare the actual death rates in these four areas with what would have been expected if these men had had the experience of London Transport male wages staff of all grades. Table 4 gives the results for men aged 55-64 during the years 1950-55. The

TABLE 4

DEATHS DUE TO LUNG CANCER 1950-55 IN LONDON TRANSPORT BUS AND TROLLEYBUS ENGINEERING STAFF (MEN AGED 55-64)

Area	Exposed to Risk (man years)	Actual Deaths		Expected Deaths*	$\frac{\text{Actual}}{\text{Expected}} \times 100$
		Number	Annual Rate per 1,000		
North-west	4,269	7	1·6	5·66	123·7
North-east	4,780	11	2·3	6·27	175·5
South-west	3,432	4	1·2	4·54	88·1
South-east	3,514	8	2·3	4·70	170·2

* The expected deaths are calculated from the experience of London Transport male wages and supervisory staff aged 55-64 in 1950-53.

highest ratios of actual/expected deaths are in the north-east and south-east segments and the lowest in the south-west segment. This is what would be expected from the theory that the amount of a carcinogen in town air depends on the density of population (possibly the number of coal fires) and that it is also driven by the prevailing wind.

It has been stressed that the number of cases involved in this investigation is small. Confirmation of the geographical effect noted amongst the engineering staff was sought but was not obtained from the figures for bus drivers and conductors who, though they travel back and forth across London, generally live near their garages and are therefore subjected to the environmental influences of their residential area. It was found that those drivers and conductors whose garages were situated in the south-west of London had the worst experience and those in the north-west the best. Thus all that can be said, on the basis of the small figures so far available, is that there is no excess of lung cancer among any group of London Transport staff such as would have been expected if diesel exhaust fumes were a serious contributory factor in producing an excess of lung cancer in urban dwellers.

THE TWO-WAY TRACK

It will thus be seen that the study of the health of the worker is a two-way track. Industry is making use of the art and science of medicine in endeavouring to discover whether, in fact, certain common

occupations affect the health of those employed in them and, if so, what measures are likely to prevent such effect. In its turn, medicine is benefiting by the generous way in which industry, particularly the large organizations, is collecting and making available data which are of considerable value to medical research.

SUMMARY

The study of the health of the worker is described as a two-way track. The contribution of medicine to industry is exemplified by the use of sickness-absence statistics. The factors influencing sickness-absence rates in occupational groups are discussed and examples are given of the value of these rates in investigating specific health problems.

The contribution of industry to medicine is illustrated by the use which is made in medical research of data collected in industry. The value is discussed of these data in the investigation of bronchitis, coronary heart disease, and cancer of the lung. The incidence is given of cancer of the lung in groups of London Transport staff which have varying exposure to diesel exhaust gases.

I wish to thank the London Transport Executive for permission to publish this paper and to use the material on which much of it was based. I also wish to record my deep appreciation to many colleagues who have given much help and encouragement, especially Dr. L. G. Norman, Chief Medical Officer, Mr. F. H. Spratling, F.I.A., and Mr. C. J. Cornwall, F.I.A.

It is probably only in the large industries that it is possible to study large enough groups of people doing the same work to make detailed analysis worth while. Also it is unusual for medical departments to have the staff to undertake the task of collecting, sorting, and tabulating the mass of data involved. Those of us who have the opportunity to do this work are deeply indebted to our colleagues, actuaries, and statisticians, for making available to us this wealth of material.

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Brit. J. industr. Med., 1957, **14**, 81.

THE NEUTRALIZATION OF SILICA TOXICITY *IN VITRO*

BY

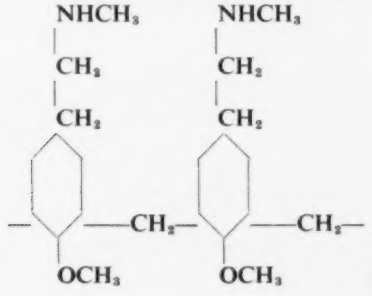
J. MARKS

From the Central Tuberculosis Laboratory, The Parade, Cardiff

(RECEIVED FOR PUBLICATION, NOVEMBER 26, 1956)

Although the capacity of aluminium to prevent experimental silicosis in animals appears to be well established (Dworski, 1955), there is no adequate evidence at present that it can influence the course of silicosis in man. Moreover, it must be administered to man by inhalation and may not be entirely innocuous itself. Recently Marks, Mason, and Nagelschmidt (1956) have described a method for evaluating antagonists to silica in tissue culture. This technique is suitable for screening large numbers of drugs, and the present paper records the encouraging results.

Organic bases are possible alternatives to aluminium, and attention was directed at first to those bases known to combine with silicic acid, *e.g.*, cytochrome c and methylene blue (James and Marks, 1956). The observation that this basic protein and basic dye precipitated polydisperse (polymerized) silicic acid recalled the well-known precipitation of the polyacidic substance heparin by protamine and toluidine blue. Several compounds known to react with heparin were therefore examined to see if they would neutralize silica toxicity. A number of these have been studied for their activity as histamine liberators (MacIntosh and Paton, 1949). A recently discovered and unusually active substance of this type, compound 48/80, proved to be of great interest. It is prepared by the condensation of p-methoxy-phenylethyl-methylamine with formaldehyde (Paton, 1951), and, existing as a mixture of low polymers, has the following general formula:—



Experimental Methods

The tissue culture technique used in the present work was that described by Marks and Mason (1956), in which cell damage is assessed by direct inspection. However, in order to provide a numerical representation of cell damage, observations were also made on the glucose consumption of tissue cultures and their dehydrogenase activity as shown by their capacity to reduce tetrazolium. For the biochemical studies, the culture technique was modified by incubating the chambers vertically, by increasing their content of medium to 2 ml., and by using 1·5 million cells per chamber when estimating glucose consumption and 4 million for dehydrogenase activity.

Glucose consumption was measured by subtracting the concentration of glucose in the tissue culture medium after three days' incubation from that in the original medium. Folin and Wu's method was used, modified by increasing the amount of phosphoric acid by 1 ml. of a 73% solution.

Triphenyl-tetrazolium chloride has been widely used to measure dehydrogenase activity in cells or their extracts. It is a soluble, colourless compound which on reduction forms an insoluble red dye. The dye can be extracted by solvents and estimated photoelectrically. In the present work, the reduction of triphenyl-tetrazolium by phagocytic cells proved to be disappointingly small, and owing to its instability the blank readings were substantial. A newer product, neotetrazolium, varies in activity in different batches but one preparation of the Sigma Chemical Co. proved to be very suitable. It was prepared by dissolving 10 mg. in 0·8 ml. of ethanol and then adding 9·2 ml. of Tyrode's solution. A slight turbidity resulted so that when dispensed the preparation was agitated to ensure a uniform dispersion. Sets of cultures were incubated in duplicate for three days. One millilitre of the supernatant medium, free of cells, was then removed from each chamber and replaced by 0·15 ml. of freshly prepared neotetrazolium. The cultures were then incubated in a 37° C. water-bath in air for four hours after which 4 ml. of acetone was added to each. The cultures were gently shaken to dissolve the dye and duplicates pooled. After centrifugation the supernatant fluids were read in a photoelectric colorimeter using a blue filter. Blank readings were obtained by substituting uninoculated medium for tissue cultures.

Details of the size distribution of the dust samples

used in the present work have been given in a previous paper (Marks *et al.*, 1956). Solutions of the organic bases were made aseptically, the alkylamines being first neutralized with hydrochloric acid. Solutions of compound 48/80, propamidine, pentamidine, and stilbamidine were made freshly for each experiment. Concentrated solutions of the other bases used were kept at 4° C. for up to three months and diluted when required. Only the histamine, protamine, and dye solutions were heated (100° C. for five minutes) after preparation.

Throughout the present work silica dust and its antagonists were added to the medium at the time the cell cultures were set up and the chambers were left undisturbed during the period of incubation.

Results

Cytology.—The following basic substances were examined for their capacity to protect phagocytic cells in tissue culture from the toxic effect of silica: cytochrome c, protamine, methylene blue, toluidine blue, compound 48/80, a number of alkyl mono-amines and diamines, histamine, pentamidine, propamidine, stilbamidine, and polymyxin B. A summary of the results is given in Table 1. Compound 48/80 was very effective in neutralizing silica toxicity. Polymyxin B and the alkylmono-amines, except methylamine, gave a definite but lesser degree of protection; the alkyldiamines gave none. The proteins and histamine were ineffective even in high concentration. The remaining compounds and methylamine also appeared to be ineffective but owing to their own toxicity they could only be tested in high dilution.

TABLE 1

PROTECTIVE EFFECT OF VARIOUS ORGANIC BASES AGAINST TOXICITY OF SILICA DUST IN TISSUE CULTURE

Base	Concentrations Tested (μg./ml.)	Degree of Protection
Compound 48/80	2·5— 80	Very high
Methylamine	2·5— 80	Nil
Ethylamine	10 —320	Trace
Propylamine	10 —320	Trace
Butylamine	10 —320	Low
Hexylamine	10 —320	Moderate
Octylamine	10 —160	Trace
Decylamine	10 —160	Trace
Ethylenediamine	20 — 80	Nil
Hexamethylene diamine	2·5— 80	Nil
Decamethylene diamine	2·5— 80	Nil
Stilbamidine	0·2— 80	Nil
Propamidine	2·5— 40	Nil
Pentamidine	1·2— 40	Nil
Histamine	2 — 32	Nil
Methylene blue	0·1— 2·5	Nil
Toluidine blue	0·1— 2·5	Nil
Polymyxin B	2·5—320	Low
Cytochrome c	120 —480	Nil
Protamine	5 —160	Nil

The test doses of silica (tridymite 2612) were 15 and 30 μg./10^4 cells

Compound 48/80 and hexylamine, the most effective of the alkylamines, were studied in detail, their protective activity being compared in most experiments with that of potassium alum. Alum, which presumably forms aluminium hydroxide at the *p*H of the medium (7·2-7·4), was previously found more protective in tissue culture than alumina or aluminium metal. The extent to which the effect of different forms of silica were neutralized is shown in Table 2 which records the results of a representative experiment. For clarity, only the effect of each antagonist at the concentration giving the greatest protection has been given in the table. This concentration varied with the different forms and amounts of silica between 10 and 40 μg./ml. for compound 48/80, between 6 and 24 × 10^{-5}M for potassium alum, and between 6 and 12 × 10^{-4}M for hexylamine. As an antagonist, compound 48/80 was as effective as alum against quartz and vitreous silica but considerably more effective than alum against tridymite and cristobalite. Hexylamine resembled compound 48/80 in being most effective against tridymite and cristobalite. Its protection against these was about equal to that of alum but it was much less effective than alum against quartz and vitreous silica.

TABLE 2

EFFECT OF COMPOUND 48/80, POTASSIUM ALUM, AND HEXYLAMINE ON TOXICITY OF DIFFERENT FORMS OF SILICA TO PHAGOCYTIC CELLS

Form of Silica	Dust Reference Number	Dust Concentration (μg./10^4 cells)	Degree of Toxicity with Optimal Concentration of Antagonists*			
			No Addition	Compound 48/80	Potassium Alum	Hexylamine
Tridymite	2612	30	+ + ±	Trace	+ ±	+ ±
,,	,,	15	+ +	0	+	+
Cristobalite	2571	30	+ + +	+	+ +	+ +
,,	,,	15	+ + ±	Trace	+ ±	+
Quartz	2531	60	+ +	+	+	+ ±
,,	,,	30	+ ±	Trace	Trace	+
Vitreous	2835	60	+ +	+	+	+ ±
,,	,,	30	+ ±	0	Trace	+

* See text.

Toxicity was assessed by the method of Marks and Mason (1956)

No evidence was found that compound 48/80 interfered with the phagocytosis of silica dust, which in its presence was found to be completely taken up by the cells. Moreover, protection against silica toxicity by compound 48/80 appeared to be specific as the drug failed to reduce the toxicity of calcium fluoride, mica, or felspar dusts.

The effect of 0·1 % compound 48/80 was examined on the solubility of three silica dusts which were kept as suspensions of 40 mg. in 10 ml. for six weeks at room temperature with occasional shaking. The results are set out in Table 3.

Compound 48/80 precipitated polydisperse silicic acid formed by neutralizing a concentrated solution of sodium silicate.

TABLE 3

EFFECT OF COMPOUND 48/80 ON SOLUBILITY OF SILICA DUSTS

Dust	Vehicle	Molybdate-reactive Silica Liberated as mg./100 ml. SiO_2	
		Control	48/80 Present
Tridymite 2612	Ringer's solution	2·5	0·2
Quartz 2530	,, ,,	5·4	0·6
Quartz 2531	Isotonic saline	3·0	0·1

The behaviour of the alkylamines was of interest since the histamine-releasing activity of the series has been described (Mongar and Schild, 1953). This activity was reported to increase with chain length up to decylamine and then decline. In the present study, alkyl mono-amines containing one, two, three, four, six, eight, and 10 carbon atoms were examined. Silica-neutralizing potency increased with chain length up to hexylamine, after which considerable surface activity appeared accompanied by an increase in toxicity which obscured the neutralizing effect on silica. Alkyldiamines containing two, six, and 10 carbon atoms were examined but found ineffective.

Glucose Metabolism.—Glucose metabolism was studied under the influence of tridymite 2612, and as antagonists compound 48/80, hexylamine, and potassium alum. The effect of tridymite on the cell cultures was greatly to decrease their glucose consumption, most of which was restricted to the early part of the incubation period. The effect of tridymite was partially or completely averted by alum and compound 48/80 as is shown in Table 4. The results

TABLE 4

DEPRESSION OF GLUCOSE CONSUMPTION OF TISSUE CULTURES BY SILICA DUST AND ITS AMELIORATION BY PROTECTIVE AGENTS

Concentration of Tridymite Dust 2612	Depression of Glucose Consumption (μg./10^6 cells)						
	Compound 48/80 (μg./ml)						
	Nil	2·5	5	10	20	40	80
40 μg./10^6 cells	350	130	0	0	0	80	210
20 μg./10^6 cells	320	0	0	0	0	70	290
	Potassium Alum ($\times 0^{-5}$ M)						
	Nil	0·75	1·5	3	6	12	24
40 μg./10^6 cells	350	—	270	250	210	180	170
20 μg./10^6 cells	320	200	120	150	40	0	0

Control cultures consumed 455 μg./10^6 cells in the same period of 3 days. It can be seen that compound 48/80 was itself toxic at the highest two concentrations tested. Alum was toxic at concentrations above 24 $\times$ 10^{-5}M.

obtained with hexylamine are not included because hexylamine itself stimulated glucose consumption in the absence of dust so that its apparent protective effect was to some extent an artefact. As in the experiments assessed cytologically, compound 48/80 proved to be more effective than alum as an antagonist to the toxicity of tridymite.

Dehydrogenase Activity.—The vitality of cell cultures at particular periods was measured by their capacity to reduce neotetrazolium, that is, their dehydrogenase activity. Tridymite 2612 or cristobalite 2571, incubated with cultures in concentrations of 3·75 to 7·5 μg. per 10^6 cells, almost abolished the dehydrogenase activity after three days. Compound 48/80 afforded almost complete protection against these doses as shown by the results in Table 5 of colorimeter readings in a typical experiment (the blank reading of 1·4 has been deducted throughout).

TABLE 5

DEHYDROGENASE ACTIVITY

Amount (μg.) of Cristobalite per 10^6 Cells	Dehydrogenase Activity with Given Concentrations of Compound 48/80 (μg./ml.)			
	Nil	10	20	40
7·5	1·3	11·1	12·0	10·2
3·75	1·9	12·6	12·2	9·5
Nil	13·9	13·0	12·9	9·7

Compound 48/80 began to be slightly toxic itself to phagocytic cells at a concentration of 10μg./ml. It was sometimes observed that the toxicity of a combination of silica dust and the drug was less than either alone, *i.e.*, silica was protecting the cells to some extent against the effect of compound 48/80. However, good protection against the effects of silica was still given by concentrations of 5μg./ml. or less of compound 48/80, which were themselves harmless.

Discussion

A survey of possible antagonists to silica by the usual methods of animal experiment would require a great deal of time and expense. The techniques described provide a convenient means of selecting compounds worth examining *in vivo*. It is proposed to test *in vivo* some of the silica antagonists found in this exploratory work but, even if they prove effective in animals, it is likely that their histamine-releasing activity would preclude clinical use. It remains to be discovered whether this activity and that of silica antagonism in organic bases can be dissociated. Both properties appear to require the possession of basic groupings and possibly also of a certain degree of surface activity and tendency to form molecular aggregates.

The solubility theory of silica toxicity, reviewed by King (1947), derives considerable support from the observation that aluminium both reduces the solubility of silica dust and protects against its toxicity. Since compound 48/80 acts like aluminium

in both respects, the theory receives support from the present work also. An objection has been made that the fibrogenic activity of different types of silica does not correlate well with their solubilities as determined in Ringer's solution. However, the more relevant information is not yet available as to the manner in which these dusts dissolve inside phagocytic cells.

The slight silica-antagonizing action of polymyxin B observed was not investigated in great detail. This substance consists of a basic polypeptide linked with a fatty acid. It is believed to release histamine *in vivo* and its toxicity has limited its dosage as an antibiotic in man.

Summary

Phagocytic cells were protected *in vitro* against the toxic effect of silica dust by compound 48/80, a histamine-releasing agent formed from p-methoxyphenylethyl-methylamine. The health of the cells was studied by direct microscopy and by measurements of their glucose consumption and dehydrogenase activity. The mode of action of compound 48/80 is not known but may depend on a reduction in silica solubility. A slight protective action was also exhibited by certain alkylmono-amines and polymyxin B.

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SILICOSIS HAZARDS IN ENAMELLING

A MEDICAL, TECHNICAL, AND EXPERIMENTAL STUDY

BY

LARS FRIBERG and HARRY ÖHMAN

From the Institute of Hygiene, Karolinska Institute, and the Department of Industrial Health, the National Institute of Public Health, Tomteboda, Stockholm, Sweden

(RECEIVED FOR PUBLICATION JULY 20, 1956)

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The exact prevalence of silicosis in Swedish enamel workers is not known, chiefly because medical inspection is not compulsory in that occupation. In a general survey of silicosis in Sweden during the period 1931 to 1953, however, 11 cases accepted by the insurance boards were found in enamelling workers and had had no other known exposure to silica (Ahlmark, Bruce, and Nyström, 1956, personal communication).

The present paper reports the prevalence of silicosis in a Swedish enamelling shop and the investigations performed in order to assess the silicosis risk.

The occurrence of silicosis among the employees in a workshop shows that unsatisfactory hygienic conditions have existed. In order to determine the current silicosis hazard dust studies are necessary. As a rule these include estimation of the atmospheric concentration of dust and of its content of quartz, but they are not completely reliable guides to the injurious properties of the dust. Tests on laboratory animals of the fibrogenic potency of the dust may provide a valuable complement to more technical investigations, especially for comparison of different dusts. In the shop we investigated, technical dust studies and animal experiments were therefore performed for appraisal of the silicosis hazard and of the need to introduce further prophylactic measures.

Enamelling Processes

The three main processes of enamelling are preparation of the enamel, spraying or dipping, and firing of the enamelled articles.

Preparation of Enamel.—The composition and technical properties of the enamels used in the shop investigated varied greatly. The method of preparation, however, was usually as follows. The powdered ingredients, including quartz feldspar, borax, metal oxides, and carbonates, were mixed in a rotating mixer and then heated in a furnace for some hours to about 800 to 1,200° C. The fused or sintered product (frit) was tapped in running water to produce an easily ground, granulated substance. This was ground while wet in a ball mill, sometimes with added substances such as quartz, clay, metal oxides, and carbonates. The aqueous mass thus obtained was ready for dipping or spraying various articles.

The enamel powder was weighed and mixed in a special shed with good general ventilation but without local exhausts. The dust produced in the various processes, therefore, spread into the atmosphere. Respirators were used by the men working in the mixing shed. Dust-reducing measures by mechanization and enclosure of the dusty operations with local exhaust ventilation are planned. The powder mixtures were fused and sintered and the wet enamel was ground out in a separate shed. In recent years exhaust devices have gradually been installed above the furnaces in this shed.

Enamelling.—Cast-iron and sheet-metal articles were enamelled by dipping or spraying. Dipping was common formerly, but spraying was mainly used at the time of investigation.

in both respects, the theory receives support from the present work also. An objection has been made that the fibrogenic activity of different types of silica does not correlate well with their solubilities as determined in Ringer's solution. However, the more relevant information is not yet available as to the manner in which these dusts dissolve inside phagocytic cells.

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The three main processes of enamelling are preparation of the enamel, spraying or dipping, and firing of the enamelled articles.

Preparation of Enamel.—The composition and technical properties of the enamels used in the shop investigated varied greatly. The method of preparation, however, was usually as follows. The powdered ingredients, including quartz feldspar, borax, metal oxides, and carbonates, were mixed in a rotating mixer and then heated in a furnace for some hours to about 800 to 1,200° C. The fused or sintered product (frit) was tapped in running water to produce an easily ground, granulated substance. This was ground while wet in a ball mill, sometimes with added substances such as quartz, clay, metal oxides, and carbonates. The aqueous mass thus obtained was ready for dipping or spraying various articles.

The enamel powder was weighed and mixed in a special shed with good general ventilation but without local exhausts. The dust produced in the various processes, therefore, spread into the atmosphere. Respirators were used by the men working in the mixing shed. Dust-reducing measures by mechanization and enclosure of the dusty operations with local exhaust ventilation are planned. The powder mixtures were fused and sintered and the wet enamel was ground out in a separate shed. In recent years exhaust devices have gradually been installed above the furnaces in this shed.

Enamelling.—Cast-iron and sheet-metal articles were enamelled by dipping or spraying. Dipping was common formerly, but spraying was mainly used at the time of investigation.

In dipping, the article was rotated in the wet enamel so that an even coating was obtained. Spraying was undertaken with special guns in booths fitted with exhaust ventilation. The enamelled surfaces were allowed to dry before firing.

Enamelling has always been carried out in a special shed. The spraying booths were rebuilt and their exhaust system improved about 15 years ago. In 1952 there were 19 such booths along one wall. The velocity of air movement in the apertures of the various booths was then 0·7 to 2·0 metres per second when spraying was not in progress, and fell 0·1 to 0·2 metres per second during spraying.

Firing.—The enamelled articles were fired in a conveyor oven, through which they were transported on a moving band. Some articles were cleaned with compressed air before firing. The passage through the oven took several hours, during which the temperature was 800 to 900° C. Before 1952 firing was undertaken in 10 small ovens situated in the enamelling shed. These are gradually being dismantled, but two remained in 1954 and were used occasionally.

Prevalence of Silicosis

On January 1, 1954, there were 35 men employed in the shop we investigated. Nine of them had been enamel workers for more than five years, 13 for more than 10 years, four for more than 20 years, and two for more than 30 years. Seven men had less than five years' exposure.

Routine medical inspection was not carried out before 1950. Since then, however, all the men have had at least two chest radiographs.

Up to the end of 1953 silicosis was demonstrated in six men and was suspected in two more. Of the six established cases (Table 1), two were then classified as third-stage, two as second-stage, and two as first-stage silicosis (Johannesburg definition, 1930). Three of these men were partially disabled and their degree of disablement was assessed by insurance boards as 33⅓%, 20%, and 15%, respectively.

As periodic radiological examinations began so recently, the length of exposure required to produce silicosis is not known. In the four silicotic enamellers, however, normal pulmonary radiographs were obtained two to nine years before silicosis was diagnosed. From the beginning of exposure to the last normal radiograph, the minimum "incubation period" for silicosis in these men was nine years (probably much more), 21, 22, and 26 years, respectively. On the other hand, an enamel grinder (Case 6) was found to have second-stage silicosis after no more than 17 years' exposure. In no case were tuberculous lesions coexistent with silicosis as judged from the appearance of the radiograph.

Technical Dust Studies

The technical studies included determination of dust concentrations in the inhalation zone during various operations and analysis of the quartz content of dust and enamels. The samples for dust counts were collected from the breathing zone of the workers for five to 10 minutes with a midget impinger. For chemical analysis air-borne dust was collected on filters. The quartz content of this dust and of the various enamels was determined by radiological diffraction of the particle fraction smaller than 5μ.

The dust counts are presented in Tables 2, 3, and 4. Manual operations with the raw constituents of the enamels yielded by far the highest dust counts (Table 2). In the production of frit the mean dust concentration was considerably lower, although very high counts were registered when the powder mixtures were transferred to the furnaces. This operation lasted only a few minutes, however, and was performed only five or six times per shift. In spray enamelling and in the firing process the dust concentrations varied greatly, but the mean value was relatively low.

Table 3 shows dust counts in spray enamelling under various conditions. The surface to be coated, for example, on washbasins and cooking utensils, is important. Spraying of inner surfaces produced

TABLE 1
SILICOSIS IN ENAMEL WORKERS*

Case	Age	Chief Occupation	Total Exposure	Negative Chest Radiograph	Silicosis			Percentage Disablement
					Stage I	Stage II	Stage III	
			Years from Start of Exposure					
1	47	Enameller	28	9	18	27		
2	49	,,	22	21	23–25			
3	66	,,	28	22	26	30		20
4	67	,,	28	26	28			
5	59	Various jobs in enamelling	33	14	16	22	29	15
6	49	Enamel grinder	16			17	19	33⅓

* Some data in the table were obtained from the survey of Ahlmark, Bruce, and Nyström (Personal communication).

TABLE 2

DUST COUNTS IN ENAMELLING PROCESSES BY IMPINGER METHOD*

Operation	No. of Samples	Dust Count			
		Minimum	Maximum	Median	Mean
Preparing enamel					
Weighing and mixing	10	28	145	82	75
Transferring powder to furnace; wet grinding	23	1	64	4	10
Enamelling					
Spraying	46	< 1	37	3	6
Dipping	11	1	7	2	2
Firing enamelled articles	18	1	21	6	8

* Counts are expressed in million particles per cu. ft.

TABLE 3

DUST COUNTS IN SPRAY ENAMELLING BY THE IMPINGER METHOD*

Type of Enamelling Operation	No. of Samples	Dust Count		
		Minimum	Maximum	Mean
Ground coat				
Inner surfaces, large articles	3	31	37	35
Outer surfaces, large articles	3	1	6	2
Outer surfaces, small articles	3	1	1	1
Cover coat				
Inner surfaces, large articles	2	15	16	16
Inner surfaces, small articles	12	1	24	9
Outer surfaces, large articles	8	1	3	2
Outer surfaces, small articles	6	2	3	2
Single coat				
Outer surfaces, large articles	7	< 1	2	1
Outer surfaces, small articles	2	1	3	2

* Dust counts expressed in million particles per cu. ft.

TABLE 4

COMPARISON BETWEEN DUST COUNTS MADE IN 1952 AND 1954 BY THE IMPINGER METHOD*

Operation	1952		1954	
	No. of Samples	Mean Dust Count	No. of Samples	Mean Dust Count
Dip enamelling	3	2	3	2
Spray enamelling				
Inner surfaces	4	12	7	12
Outer surfaces	10	2	29	2
Firing enamelled articles	8	6	10	8

* Dust counts expressed as million particles per cu. ft.

much higher dust counts than did spraying of outer surfaces. This was because the enamel aerosol has a greater tendency to " rebound " from inner surfaces and because the enameller as a rule must lean into the spraying booth, which is unnecessary in spraying outer surfaces. Dust counts during the latter operation were on the whole independent of the size of the coated article.

Enamelling by dipping (Table 2) gave the lowest mean dust counts of all, although no special exhaust ventilation was in use.

Work at the firing ovens involved three dusty processes—cleaning with compressed air, brushing the inside of the articles, and handling the boards on which the spray-enamelled goods were placed for transport to the ovens. These boards gathered a deposit of dry enamel powder, which was readily whirled up into the atmosphere.

In certain processes the dust counts made in 1954 could be compared with counts which had been made in 1952. The dust concentrations were similar (Table 4). This tallied with the lack of change in working methods and in ventilation.

Quartz Analyses.—Quartz analyses were made on air-borne dust, on deposited dust, and on various enamels.

The results are presented in Tables 5, 6, and 7.

TABLE 5

QUARTZ CONTENT IN THE PARTICLE FRACTION < 5μ OF AIR-BORNE DUST

Operation	No. of Samples	Mean Quartz Content (%)
Preparing enamel		
Weighing and mixing	2	43
Transferring powder to furnace; wet grinding	1	46
Spray enamelling		
Ground coat	1	58
Cover coat	2	< 5
Firing enamelled articles	2	11

TABLE 6

QUARTZ CONTENT IN THE PARTICLE FRACTION < 5μ OF VARIOUS ENAMELS

No.	Type of Enamel	No. of Samples	Mean Quartz Content (%)
1	Ground coat	1	52
2	" "	3	57
3	" "	2	39
4	Cover coat	3	< 5
5	" "	1	< 5
6	" "	2	15
7	" "	2	< 5
8	Single coat	2	13

TABLE 7

QUARTZ CONTENT IN PARTICLE FRACTION < 5μ OF DEPOSITED DUST

Site of Dust Deposit	No. of Samples	Quartz Content (%)
Spraying booth	1	6
Space above conveyor oven	1	21
Beams of conveyor oven, ball mill and smelting furnace	1	18
Locker in enamelling hall	1	5

In the air-borne dust (Table 5) quartz could not be demonstrated during spraying of cover-coat enamel. The other processes, however, with the exception of firing the enamelled articles, produced dust with high quartz contents. Of the enamels studied (Table 6), those used for the ground coat had the highest content of quartz (39, 52, and 57%). Of

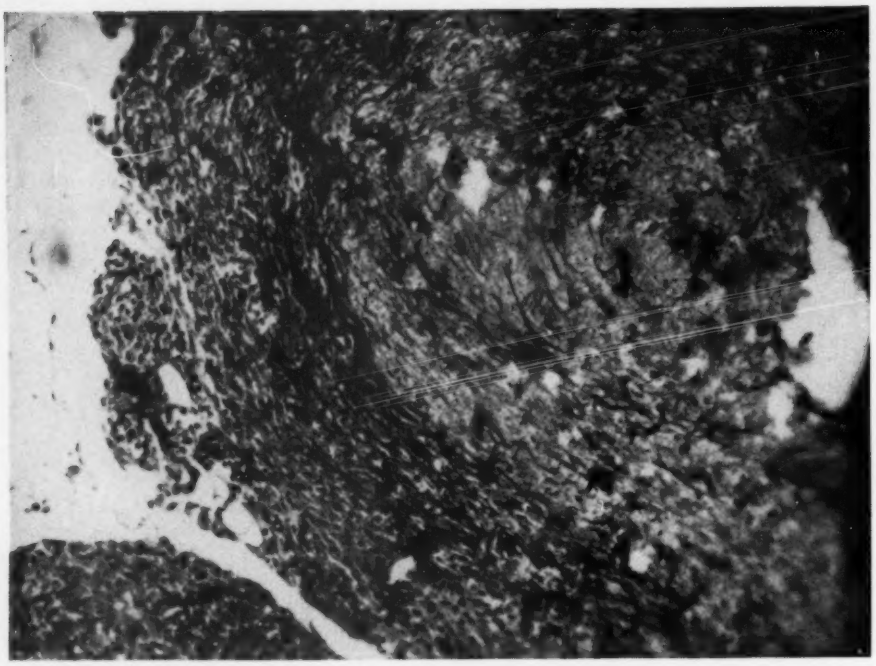

FIG. 1.—Epithelioid-cell granuloma (omentum) with fibrosis and concentrically-layered collagen fibrils nine months after injection of enamel No. 2. Weigert haematoxylin-Hansen. × 150.

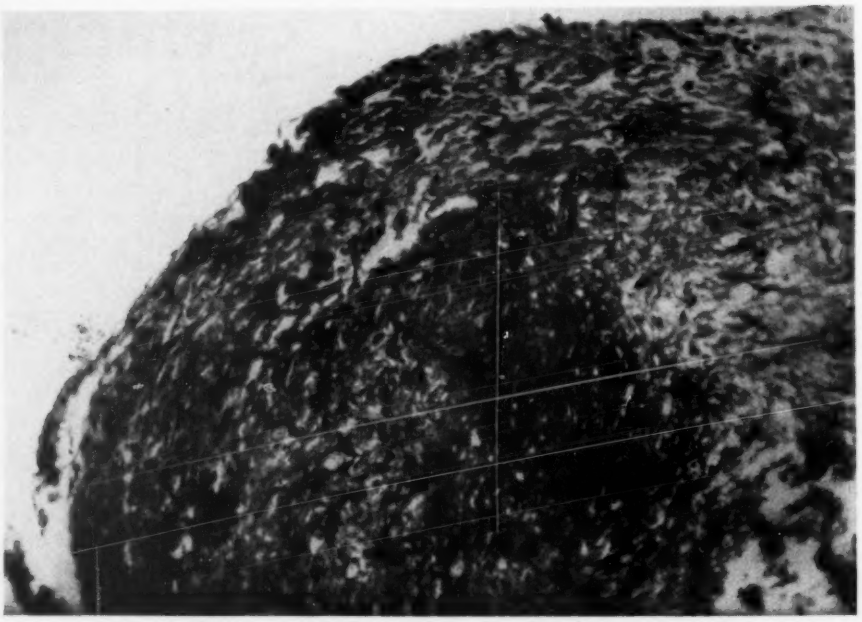

FIG. 2.—Epithelioid-cell granuloma (omentum) with severe fibrosis and concentrically-layered collagen fibrils two months after injection of pure quartz powder (No. 9). Weigert haematoxylin-Hansen. ×150.

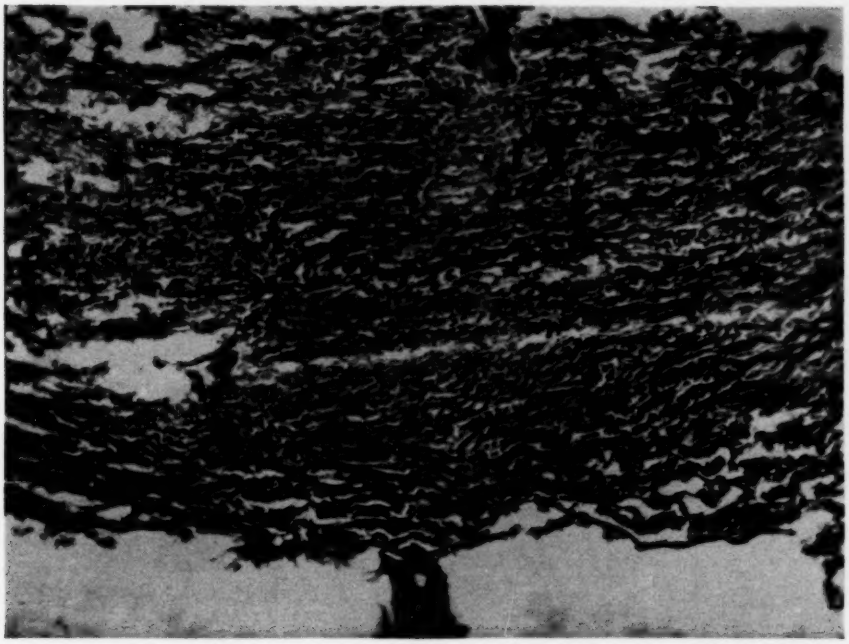

FIG. 3.—Necrotic granuloma (omentum) with infiltration of lymphocytes and leucocytes and severe fibrosis with concentric collagen lamellae two months after injection of enamel No. 7. Weigert haematoxylin-Hansen. × 150.

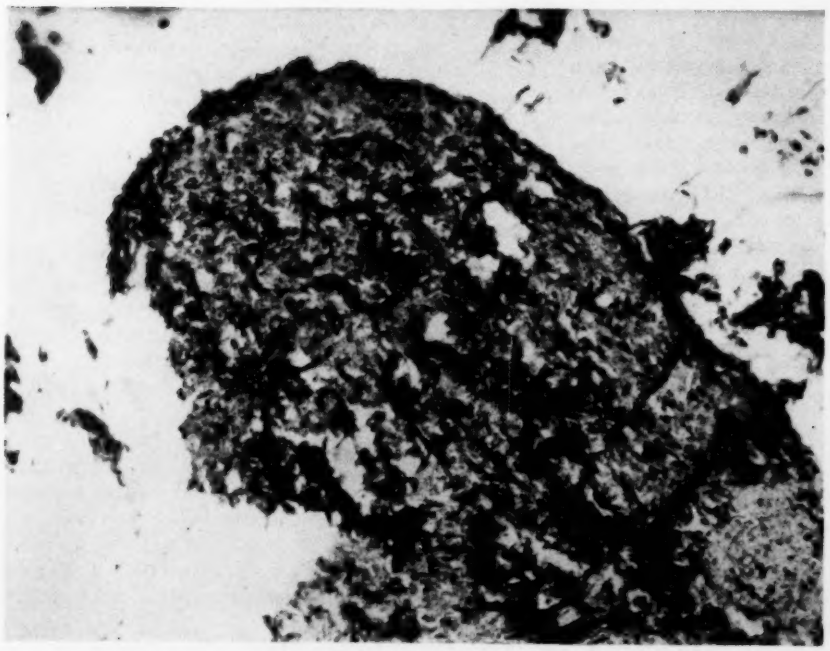

FIG. 4.—Epithelioid-cell granuloma (omentum) with mild fibrosis nine months after injection of enamel No. 8. Weigert haematoxylin-Hansen. × 150.

four types of cover coat only one contained quartz, and that in low concentration (15%). A single-coat enamel (an enamel sprayed without ground coat on sheet metal or cast iron) contained 13% quartz.

Animal Experiments

The fibrogenic potency of six of the enamels reported in Table 6 (Nos. 2, 3, 4, 6, 7, and 8) was tested in rats. These were the enamels most commonly used during the period of our investigation. Control tests were undertaken with pure quartz powder (No. 9). The approximate percentages of quartz in the enamel powders were 57 (No. 2), 39 (No. 3), < 5 (Nos. 4 and 7), 15 (No. 6), and 13 (No. 8).

Enamel powder was suspended in sterile physiological saline solution in a concentration of 3·7 g. per 100 ml. The fibrogenic potency was estimated from the tissue reaction after a single intraperitoneal injection (2 ml. = 75 mg. enamel powder) according to the method of Miller and Sayers (1934).

Each type of enamel was tested on about 30 rats, the groups being numbered in conformity with the enamels. In each group four rats were killed after two weeks, one, two, three, six, and nine months. The peritoneum and omentum were examined macroscopically and in about half of the rats microscopy was also performed.*

Macroscopic Changes.—These were invariably most severe in the omentum, but frequently occurred also in the peritoneum. Changes appeared from two to four weeks after the injection and consisted of white or green (some of the enamels were green) pinpoint- to pinhead-sized, more or less firm, nodules. The largest and firmest nodules were seen in groups 2 and 9, and the smallest in groups 4 and 7, where the lesions had an almost floury appearance. Progression was clearly observed only in group 9 and occurred two months after the injection. Some apparent regression of the lesions was seen in groups 6 and 7.

Microscopic Changes.—These were observed in all the groups, but there were some distinct differences.

In groups 2, 3, and 9 (57, 39, and 100% quartz respectively) the microscopic findings were nearly the same. The lesions were granulomatous with moderately abundant epithelioid cells. After two to three months fibrosis also developed, which intensified and gradually took on a typical silicotic appearance with concentric layering (Fig. 1 and 2). Such changes first occurred in group 9.

Groups 4 and 6 both showed granulomatous lesions with abundant foreign bodies, but with insignificant numbers of epithelioid cells. Fibrosis developed, especially in group 6. It was not silicotic in type, however, but most closely resembled foreign-body granuloma.

In groups 7 and 8 (Fig. 3 and 4) the lesions were more heterogeneous. Group 7 showed small granulomata with scanty epithelioid cells. Small fibrous lesions with concentric layering were observed, two, six, and nine months after the injection, but in some sections the fibrous lesions displayed central necrosis with some leucocytic infiltration. In group 8 a section two months after the injection showed epithelioid-cell granuloma with fairly typical silicotic fibrosis. Subsequently, however, epithelioid-cell granuloma was the only demonstrable lesion in this group, except for mild, non-silicotic fibrosis in the rats killed after nine months.

Enamels 2 and 3 (57 and 39% quartz respectively) and the pure quartz powder thus gave rise to severe silicotic lesions and enamels 7 and 8 (< 5 and 13% quartz respectively) produced changes of suspected silicotic type. Silicosis was not demonstrated in the rats injected with enamels 4 and 6 (< 5 and 15% quartz respectively).

Discussion

In the past 20 years six established and two suspected cases of silicosis have occurred in a Swedish enamelling shop which now employs 35 men. The true attack rate of silicosis cannot be determined, chiefly because it is not known how many of the men who left this occupation subsequently developed the disease. Periodic medical inspection has only recently been introduced.

That silicosis is an important medical problem in enamel workers is nevertheless shown by its partially disabling effects in three of the men. The period of exposure required to produce silicosis was probably at least 15 to 20 years, except in preparing enamel powder, where one man showed second-stage silicosis after (probably) less than 17 years' exposure. In no case was silicosis complicated by tuberculosis.

It is not possible solely from the known cases of silicosis to determine accurately which processes are dangerous. The composition of the enamel varied and many of the men had taken part in more than one process. The rapidly progressive silicosis in the man mainly engaged in preparing enamel powder, may, however, indicate special risks in this work.

The dust studies indicate the aetiology of the silicosis and provide a good estimate of the future risks. Thus, men engaged in preparing enamel and

* The microscopic examinations were carried out by Professor Gösta Hultquist, of the Institute of Pathology, Uppsala.

in spraying ground-coat enamel on inner surfaces are exposed to fairly high concentrations of a dust containing about 50% quartz, and presumably in former years they were even more severely exposed. By themselves these investigations strongly suggest that such work has entailed and still entails considerable silicosis hazards. Confirmatory evidence was furnished by the animal experiments, in which the two ground-coat enamels tested (containing 57% and 39% quartz) displayed distinct fibrogenic potency and produced lesions differing relatively insignificantly from those in control tests with pure quartz.

It is considerably more difficult to determine how far spraying with cover-coat and single-coat enamel contributed to the development of silicosis and whether such work now carries a risk of the disease. Fairly high dust concentrations undoubtedly occur —and in earlier years probably were substantially higher—in enamelling of inner surfaces. On the other hand, quartz could not be demonstrated ($< 5\%$) in three of the cover-coat enamels. The fourth contained 15% quartz. The single-coat enamel contained only 13% quartz.

If one appraises the silicosis hazard from the dust concentrations found and the generally accepted maximum allowable concentrations (50 and 20 million particles per cu. ft., respectively, for dust containing < 5 and 5 to 50% quartz), cover-coat enamelling carries a minimal risk. Certain factors, however, indicate that a more cautious approach may be advisable. Thus, as mentioned in the introduction to this paper, silicosis has been reported to result from exposure to enamel dust containing little or no quartz. Nor do we know whether the permissible concentrations of dry dust should be applicable to the aerosol formed in spray enamelling. Finally, in our animal experiments lesions of suspected silicotic appearance were produced by one of three cover-coat enamels, although quartz could not be demonstrated ($< 5\%$). Similar changes were evoked by the single-coat enamel (only 13% quartz).

Hence it is not unlikely that at least two of the enamels were more toxic than their quartz contents indicated, and we consider that attention should be directed to the operations (spraying of inner surfaces) in which relatively high dust concentrations occur. This opinion is in conformity with the views expressed by Hatch (1955). On the basis of an extensive investigation he criticized the current rule of automatically relating the silicosis hazard to the amount of quartz in the dust. Hatch suggested the following norms for maximum allowable concentrations: < 5 million particles per cu. ft. in occupations with a well-documented risk of silicosis, 5 to 10 million particles per cu. ft. when the risk is less pronounced, 25 to 50 million particles per cu. ft. for dust which has given rise only to simple pneumoconiosis, *e.g.*, anthracosis, and < 100 million particles per cu. ft. for dust which has not produced demonstrable pathological changes. This interesting principle must, of course, be limited to occupations from which satisfactory clinical experience is available.

Summary

Medical, technical, and experimental investigations of the silicosis hazards in a Swedish enamelling shop which now employs 35 men are described.

In the last 20 years six established and two suspected cases of silicosis have occurred in men exposed to no other similar risk. In three of the men the disease caused partial disablement.

The most dangerous operations appeared to be the preparation of enamel powder and spraying ground-coat enamel on inner surfaces. The men were exposed to fairly high concentrations (mean values 10-75 million particles per cu. ft., impinger method) of a dust containing about 50% quartz. This dust displayed, with the method of Miller and Sayers (1934), distinct fibrogenic potency in rats and produced lesions in omentum and peritoneum differing insignificantly from those in control tests with pure quartz.

It was more difficult to determine how far spraying with cover-coat and single-coat enamel had contributed to the development of silicosis and whether such work now carries a risk of the disease. The dust concentrations were fairly high in some operations (mean values 9-16 million particles per cu. ft., impinger method), but quartz was present in small amount or could not be demonstrated ($< 5\%$). Two of the enamels produced suspected silicotic lesions in rats. It was therefore considered not unlikely that these two enamels were more toxic than their quartz contents indicated. Attention should be directed to the operations (such as spraying of inner surfaces) in which relatively high dust concentrations occur.

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SOME FACTORS INFLUENCING THE RESPONSE OF INDUSTRIAL WORKERS TO MASS RADIOGRAPHY

BY

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(RECEIVED FOR PUBLICATION OCTOBER 5, 1956)

The measure of control of respiratory tuberculosis in industry through mass radiography, assuming the service to be accepted and organized at regular intervals, depends mainly on how great a proportion of employees volunteer for radiological examination at any one time. The response varies between different factories and in our experience may be from 5 to 100%. Such a wide range cannot be explained solely by differences in the attitude of individual workers. There are obviously other factors to be considered. One of the more tangible factors which may affect participation in a mass radiography survey, and one which could influence both employees and management, is the distance which volunteers have to travel from their place of work to the unit. It is reasonable to assume that the nearer the unit is situated to the employees, the better the response will be. In practice, however, it is not easy to move rapidly the complicated machinery of a radiography unit, and the premises of small factories may be inadequate, with the result that surveys of small groups of employees may prove uneconomical. It is, therefore, a matter of some importance to explore the extent to which attendance figures depend on the distance separating examinees from the unit in relation to the size of the factory concerned.

With this aim in view, a mass radiography survey covering a compact industrial estate was organized in 1955 on the following lines:—

(1) At 52 factories the unit operated successively in the centre of a number of areas, the radius of which did not exceed 100 yards. (2) Twenty-four factories were visited individually, with the unit operating in the factory grounds. The attendance figures were then compared with those of the 1953 survey in which the unit worked on a single site and all the factories were situated within approximately one mile of it. In both surveys the same 76 factories were involved and the same type of propaganda was used. In only four factories was the number of employees in 1955 much different from that in 1953. The results are shown in Table 1.

There was no appreciable difference between the responses in the two surveys. The slightly higher response for smaller factories in 1955 was compensated by a slightly lower response in the larger establishments. Both surveys covered the same factories, with little change in the age and sex structure of their respective employees. In our experience repeat surveys result, if anything, in a higher response than first surveys. It appears, therefore, that by bringing the unit almost to the doorstep of the factory, no improvement in attendance was

TABLE 1

RESPONSE OF VOLUNTEERS ACCORDING TO DISTANCE FROM MASS RADIOGRAPHY UNIT AND SIZE OF FACTORY

Factories Employing	Unit Operating from Site of Radius One Mile from Farthest Factory				Unit Operating in Sectors of Radius 100 Yards			
	1953				1955			
	No. of Firms	No. of Employees	No. Radiographed	Percentage Response	No. of Firms	No. of Employees	No. Radiographed	Percentage Response
Less than 25 persons	14	210	125	60	13	214	137	64
26–50 ,,	13	529	291	55	12	449	266	59
51–200 ,,	20	1,887	989	52	22	2,417	1,116	46
201+ ,,	5	1,583	837	53	5	1,224	568	46
Total	52	4,209	2,242	53	52	4,304	2,087	49

achieved, and no support was found for the contention that attendance and distance are closely inter-related.

Table 1 is also of interest because there is a suggestion of a response gradient favouring the smaller factories. This is surprising in view of the existence of better welfare facilities and health education in larger industrial establishments. It is also unexpected because in the industrial estate concerned the larger factories usually employ a higher proportion of women and young men and these groups generally respond more readily to mass radiography. Nevertheless, better attendances were obtained in the smaller factories. An explanation for this anomaly may perhaps be found in the differences between the ratio of unskilled to skilled workers in factories of different sizes. It is generally accepted that this ratio increases with the size of factories. At the same time it is known that the response to mass radiography is lowest in unskilled workers (Brett, Benjamin, Wallace, and Freeman 1956). It is also possible to speculate on the more personal contact between management and workers in small factories and its effect on attendance figures. Probably all these factors took some part in producing the results shown in the present analysis.

Although the percentages shown in Table 1 indicate the general levels of response in different sizes of factory, the fluctuations from these levels are much greater in the smaller factories. Clearly a small variation in the number attending may have a large effect on the percentage response for a small factory. The wider scatter of attendances in the small factories is illustrated in Fig. 1. Table 1, therefore, indicates only the general trend and cannot be used to predict the response in an individual small factory.

In the second part of the 1955 survey 24 factories were visited individually. The results are given in Table 2.

In contrast to Table 1 the response from these factories showed an average increase of 20% compared with the 1953 survey. A repeat survey might be expected to give this result. However, it cannot be explained merely by the proximity of the unit, for the following reasons:—(1) Distance from the unit does not appear to affect attendances. (2) The number of those who volunteered for radiological examination when called upon by the internal organizing body of the factory (managements and shop stewards) did not increase in the course of the survey, when it might have been expected that the sight of the unit at work would act as an added stimulus to those who could not make up their minds. Nor is it likely that the attitude of workers to mass radiography varies much according to place of employment. The main variable element appears to be the attitude of managements; this, however, is not directly accessible to analysis. Yet experience in mass radiography suggests that it is the cooperation of managements that decides the success of a survey. Managements are aware of the many valuable aspects of mass radiography, but they are equally alive to the degree of interruption caused by a survey; the balance of the two factors finally decides their attitude. It would not be unreasonable to assume that managements would take a greater interest in, and perhaps use their full administrative machinery to promote, a survey which, being on their premises, remains under their visual control. If this interpretation is true, the figures in Table 2 fall into a logical pattern.

The findings of this survey lead to the conclusion that industrial workers who want to avail themselves of mass radiography will not be deterred by having to travel a reasonable distance from the unit, while those who, for reasons of their own, refuse to take part in a survey, will not be made to do so by bringing the unit to their doorstep. Our experience in " open sessions " supports this contention for the public at large. The survey did, however, suggest that managements do influence a proportion of those who would otherwise not have come forward when the unit is in the factory grounds. This means that factories employing 50 workers and over should be

TABLE 2

COMPARISON OF RESPONSE OF VOLUNTEERS FROM CERTAIN FACTORIES WHEN VISITED INDIVIDUALLY BY M.R. UNIT (1955) AND WHEN M.R. UNIT OPERATED FROM A SINGLE SITE (1953)

Factories Employing	Unit Operating from Site of Radius One Mile from Farthest Factory				Factories Visited Individually			
	1953				1955			
	No. of Firms	No. of Employees	No. Radiographed	Percentage Response	No. of Firms	No. of Employees	No. Radiographed	Percentage Response
Less than 25 persons	None	—	—	—	—	—	—	—
26–50 ,,	None	—	—	—	—	—	—	—
51–200 ,,	6	768	434	57	6	750	520	69
201 + ,,	18	11,359	5,543	49	18	12,756	8,746	69
Total	24	12,127	5,977	49	24	13,506	9,266	69

FIG. 1a

FIG. 1.—Response to mass radiography in relation to size in 52 individual factories.
(*a*) Unit operating from site of radius one mile from farthest factory (1953).
(*b*) Unit operating in sectors of radius 100 yards (1955).

visited individually, with the unit operating on the premises, however difficult it may be to put such a policy into practice.

Summary

Mass radiography surveys conducted on sites varying in distance from 100 yards to one mile from places of work showed that the siting of the unit did not influence the response of factory workers.

The increased attendance in surveys carried out on factory premises is attributed to the cooperation of managements.

I wish to thank Dr. C. M. Fletcher, Senior Lecturer in Medicine, Post-Graduate Medical School of London, and Mr. B. Benjamin, Chief Statistician, General Register Office for their valuable criticism, and Dr. A. Austin Eagger, Medical Director, Slough Industrial Health Service, for his help in organizing the survey. I should also like to pay tribute to Miss B. Butcher, Organizing Secretary of the Unit, for the ingenious and economical way which she adopted in arranging the survey.

FIG. 1b

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RADIOLOGICAL SURVEYS OF WORKING QUARRYMEN AND QUARRYING COMMUNITIES IN CAERNARVONSHIRE

BY

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(RECEIVED FOR PUBLICATION JANUARY, 1957)

Interest in the possible occupational lung diseases associated with slate-quarrying appears to date from the Registrar-General's Decennial Supplement, 1921, on Occupational Mortality (Registrar-General, 1927). Britten's review (Britten, 1928) showed that slate-masons and slate-workers had a significantly raised mortality from respiratory tuberculosis although it was much lower than that of tin- and copper-miners. At roughly the same time, Wade (1927) called attention to the excessive mortality from tuberculosis of the slate-workers in the Gwyrfai rural district in North Wales. Since then, most of the references in the international literature about this subject have referred to Wales, but descriptions of cases of pneumoconiosis in slate-quarry workers have been published in other countries.

In France, Feil (1935) found relatively little pulmonary disease amongst slate-workers in Mayenne and Anjou. He attributed this to the low content of free silica (7%) in the slates there. In Germany, Schairer (1940) described egg-shell calcification in two slate workers; Koelsch (1950) described the radiographic appearances, and Ceelen (1951) described one case. In Italy, Frola (1942) described the radiographic appearances in 34 slate-workers; and cases have been reported from the United States by Rogers (1932) and Mansur (1951).

In Wales, Wade's report was followed by the survey by Sutherland and Bryson (1930) who found clinical evidence of pulmonary fibrosis amongst 56 out of 120 slate-quarrymen. A few years later Chalke (1933) showed that 28% of the tuberculous males in the county of Caernarvon were slate-workers while this industry only absorbed 11% of the male population. Davies (1939) reported the results of examining 117 slate-workers chiefly from Merionethshire and, as a result, silicosis amongst slate-workers who worked underground was scheduled under the Workmen's Compensation Act. The section of the industry involving work above ground was not so scheduled. Davies (1942) reviewed silicosis amongst coal-miners and slate-workers in Wales. Later a committee of the Ministry of Works, under the chairmanship of Mr. F. Rees, reported on the Welsh slate industry (Ministry of Works, 1947). They considered that the fear of pneumoconiosis was preventing men entering the industry and recommended that the pneumoconiosis problem should be attacked at once.

The relative position of tuberculosis mortality in the Gwyrfai rural district has not improved since the time of Wade's original investigation. In 1928 the tuberculosis death rate was 285 per 100,000 persons compared with a figure of 96 for England and Wales. In 1951 the figures were 110 and 31 respectively.

In 1952 there was therefore evidence that pneumoconiosis—probably silicosis—was prevalent amongst slate-workers in North Wales, and that the tuberculosis death rate in the slate-quarrying areas was abnormally high. For these reasons, the Gwyrfai Rural District Council asked the Welsh Board of Health for an investigation, and as a result a survey was carried out by the Mass Radiography Service of the Welsh Regional Hospital Board in 1952-53, which is the subject of this paper.

OBJECTIVES OF MASS RADIOGRAPHY SURVEY 1952-53

The objectives of the survey were:—

(*a*) To ascertain the prevalence of pneumoconiosis amongst the slate-quarry workers; (*b*) to ascertain the prevalence of active pulmonary tuberculosis amongst quarry workers; (*c*) to determine whether any important relationship exists between (*a*) and (*b*); (*d*) to ascertain the prevalence of pulmonary tuberculosis amongst quarry and ex-quarry workers, living in "quarrying" communities; and (*e*) to ascertain the prevalence of pulmonary tuberculosis amongst workers not concerned with quarrying in the male population of the quarrying towns and to

compare this with the prevalence amongst quarry workers and ex-quarry workers.

PART I: SURVEY OF WORKING QUARRYMEN

Extent of the Survey

In order to achieve these objectives the aim was to radiograph as near 100% of the quarry workers at their place of work as possible. To radiograph ex-quarrymen, quarrymen not well enough to work, and males not engaged in quarrying it was necessary to carry out surveys of the "total community" type (Cochrane, Cox, and Jarman, 1952) in a limited number of the quarrying towns in the district. These surveys, which were carried out from November, 1953, to February, 1954, became an integral part of the work and are described in Part II of this paper.

Planning and Propaganda

The first stage in the survey was to radiograph the working quarrymen. The report of the Ministry of Works (1947) shows that slate quarrying is the main industry in this area of North Wales, and there are few opportunities of employment in other industries. This naturally renders the men more than ordinarily sensitive to any procedure which might appear as a threat to their occupational security. It was emphasized both from the management and trade union that it would be difficult to obtain a 100% response from the quarry workers, who are traditionally conservative in their outlook. It was therefore essential to obtain the fullest cooperation from both management and workers of the five slate quarries concerned. Joint consultations were arranged between the Welsh Sectional Industrial Council for the Slate Quarrying Industry (which includes representatives of workers and management), the chest physician, the Mass Radiography Service, and representatives from other interested medical services, at which the objectives of the scheme were discussed. Talks in English and by one of us (J.G.J.) in Welsh about the scheme and its objectives were given at places of work and in the canteens. Articles appeared in the local press, in English and Welsh, and an "on-the-spot" broadcast was radiated from the Welsh Region of the B.B.C. One of the most important measures which contributed to the success of the survey was, however, the personal canvassing of workers who had failed, without such persuasion, to attend. The mass radiography unit was taken to the place of work in the quarries and was moved from one "level" to another in order that the workers would not have to walk far from their place of work to be radiographed. The highest level at which the unit worked was in the Dinorwic quarry opposite Snowdon at a height of 2,000 feet above sea-level.

Choice of Film

It was recognized that in a radiological survey to ascertain the prevalence of pneumoconiosis full-sized films should be used. Unfortunately, an acute shortage of such films existed at the time of the survey, and a 70 mm. "odelca" mirror camera attachment with a Watson 4-valve mobile unit was therefore used.

Reading of the Films

It has been shown that considerable error can arise in the reading of miniature and even full-sized radiographs when these are interpreted by a single reader. The films were, therefore, read by three of us independently; differences were resolved by discussion and agreement between the three readers in conference.

Categories of Pneumoconiosis

The classification of pneumoconiosis cases was carried out in accordance with the categories formulated by Fletcher, Mann, Davies, Cochrane, Gilson, and Hugh-Jones (1949) and accepted internationally after the I.L.O. conference on pneumoconiosis at Sydney in 1950 (Cochrane, Davies, and Fletcher, 1951). This classification is purely radiological and is not concerned with disability.

Disposal of Cases

All cases in which pulmonary tuberculosis or new growth was suspected by one or more of the three readers (with or without the presence of pneumoconiosis) were given appointments for an interview with one of us (H.E.S.) at the quarries, and were referred to the chest physician (J.G.J.), through their general practitioners, for further investigation. All cases of pneumoconiosis with massive fibrosis were considered as suspect cases of active pulmonary tuberculosis for this purpose. Appointments were also offered to all cases of pneumoconiosis of category 2 and upwards. At these interviews laryngeal swabs and/or sputum specimens were taken from those patients who were willing to cooperate in order to attempt an assessment of hidden tuberculous infectivity.

Cases of suspected pulmonary tuberculosis sent to the chest clinic were classified as "active" or "active and infectious" on the basis of bacteriological findings and radiological changes up to January 1, 1955. This was in accordance with the normal chest clinic practice, and cases were graded A or B, I, II, or III (Ministry of Health classification, Memorandum 37/T, Revised).

The follow-up of cases referred to the chest physician was necessarily slow. Out of the 219 men referred to the chest clinic for observation and assessment, 27 failed to attend, and this, of course, represents a serious shortcoming of this work.

Results

Two thousand four hundred and thirty-two working quarrymen, 90% of the men employed, were radiographed. Table 1 shows the classification

TABLE 1
ANALYSIS OF CHEST FILMS OF WORKING QUARRYMEN

Category of Pneumoconiosis	Other Complications				Total
	Suspected Pulmonary Tuberculosis	Suspected New Growth	Other Pulmonary Abnormalities	None	
Category 0	30	2	73	1,573	1,678
Category 1	100	3	—	448	551
Category 2	53	–	1	102	156
Category 3	15	1	—	16	32
Progressive massive fibrosis	15	–	—	—	15
Totals	213	6	74	2,139	2,432

of the films for pneumoconiosis, suspected pulmonary tuberculosis, suspected new growth, and other pulmonary abnormalities, and Table 2 the prevalence of pneumoconiosis by age.

TABLE 2
ANALYSIS OF CHEST FILMS OF WORKING QUARRYMEN BY AGE AND CATEGORY OF PNEUMOCONIOSIS

Age Group (years)	Category of Pneumoconiosis					Total
	0	1	2	3	P.M.F.	
15–24	280 96·2%	10 3·4%	1 0·4%	—	—	291
25–34	374 87·4%	53 12·4%	1 0·2%	—	—	428
35–44	405 70·8%	137 24%	26 4·5%	3 0·5%	1 0·2%	572
45–54	364 58%	205 32·7%	42 6·7%	11 1·8%	5 0·8%	627
55–64	179 49·6%	108 29·9%	57 15·8%	13 3·6%	4 1·1%	361
65 +	76 49·7%	38 24·8%	29 18·9%	5 3·3%	5 3·3%	153
Total:	1,678 69·0%	551 22·7%	156 6·4%	32 1·3%	15 0·6%	2,432

The 213 cases classified as " suspected pulmonary tuberculosis " and six cases of possible new growth were offered interviews. All attended with the unfortunate exception of eight cases of suspected pulmonary tuberculosis. For the purpose of statistical analysis these eight cases are included in those who failed to attend the clinic in Table 3.

Prevalence of Pulmonary Tuberculosis in Working Quarrymen.—Table 3 shows the final classification on January 1, 1955, of the 219 working quarrymen

TABLE 3
CLASSIFICATION OF 219 WORKING QUARRYMEN REFERRED TO CHEST CLINIC

Active pulmonary tuberculosis (with and without pneumoconiosis)	27
Healed pulmonary tuberculosis	22
Progressive massive fibrosis	12
Pneumoconiosis	81
Other pulmonary abnormalities	19
Normal	31
Failed to attend	27
Total	219

referred to the chest clinic for further assessment and diagnosis. It will be seen that 27 were considered to be suffering from active pulmonary tuberculosis. Table 4 shows the sub-division of these 27 cases by age, category of pneumoconiosis, and sputum state. All cases with pneumoconiosis, category 2 and above, were also offered interviews. Laryngeal swabs and sputum specimens were obtained from 166 working quarrymen including 10 cases of progressive massive fibrosis (P.M.F.). Table 4 gives the results of the

TABLE 4
RESULTS OF LARYNGEAL SWABS AND SPUTUM TESTS

Category of Pneumoconiosis	No. of Cases Swabbed and/or Sputum Tested	No. of Swabs Taken	No. of Sputum Tests Obtained	No. of Laryngeal Swabs Positive	No. of Sputum Tests Positive
Category 2	132	174	68	0	0
Category 3	24	35	19	0	0
P.M.F.	10	16	6	1	1
Totals	166	225	93	1	1

laryngeal swabs and sputum tests carried out at the unit. Of the 10 men with P.M.F. who attended, one gave a positive sputum. Of 736 cases of P.M.F. among coal-miners and ex-coal-miners in the Rhondda Fach 1·1% gave a positive sputum (Cochrane *et al.*, 1952). The number of P.M.F. cases tested bacteriologically from the quarry workers is, however, too few for the difference to be statistically significant. None of the 156 cases of simple pneumoconiosis had a positive sputum.

It should be pointed out, however, that of the seven category 2 and 3 cases diagnosed at the clinic as suffering from active pulmonary tuberculosis, five had a positive sputum (Table 5). This would suggest that the laryngeal swabbing and sputum testing carried out on a single occasion at the unit were technically deficient as methods of discovering the tubercle bacillus when compared with similar tests carried out periodically at the chest clinic.

Discussion

Pneumoconiosis.—The figures for prevalence of pneumoconiosis amongst working quarrymen can

TABLE 5

CASES DIAGNOSED AS ACTIVE PULMONARY TUBERCULOSIS AT THE CHEST CLINIC ANALYSED BY AGE, CATEGORY OF PNEUMOCONIOSIS, AND SPUTUM STATE

Age (years)	Category of Pneumoconiosis										Total
	0		1		2		3		P.M.F.		
	Sputum +	Sputum —	Sputum +	Sputum —	Sputum +	Sputum —	Sputum +	Sputum —	Sputum +	Sputum —	
25–34	1	1	1	1	–	–	–	–	–	–	4
35–44	1	1	1	–	–	–	–	–	–	–	3
45–54	1	1	–	4	2	1	–	–	–	–	9
55–64	1	3	–	–	1	1	1	–	1	–	8
65 +	–	1	1	–	1	–	–	–	–	–	3
Totals	4	7	3	5	4	2	1	–	1	–	27

be compared with those for the 6,026 miners and ex-miners in the Rhondda Fach radiological survey (Cochrane *et al.*, 1952). The total prevalence of pneumoconiosis, especially if cases of category 1 are excluded, is much lower amongst working quarrymen than amongst miners and ex-miners in the Rhondda Fach. It should be noted here, however, that the difference in prevalence between quarry workers and miners might not have been so marked had ex-quarry workers been included in the survey. The total prevalence of pneumoconiosis of categories 2 and 3 was 83·5 per 1,000 examined amongst working quarrymen. In the Rhondda Fach, for 6,026 miners and ex-miners, the prevalence of similar cases was about 300 per 1,000 examined. The prevalence of pneumoconiosis is, therefore, much lower amongst the working quarrymen than amongst miners and ex-miners in the Rhondda Fach.

Tuberculosis.—With the reservation that 27 of the 213 cases of suspected pulmonary tuberculosis failed to attend the chest clinic, the prevalence of pulmonary tuberculosis amongst working quarrymen can be compared with that of the Rhondda Fach survey in certain particulars. Infectious tuberculosis amongst working quarrymen can be compared with that amongst surface and underground workers in four Rhondda Fach collieries (Cochrane *et al.*, 1952). In 2,911 surface and underground coalminers, four cases of infectious tuberculosis were discovered, a rate of 1·4 per 1,000. The rate of sputum-positive cases in working quarrymen was at least 5·3 per 1,000.

It would appear, therefore, that in working quarrymen, although the total prevalence of pneumoconiosis and its radiological severity are lower than in miners and ex-miners, the prevalence of active pulmonary tuberculosis is higher. The rate for active tuberculosis in working quarrymen is 11·1 per 1,000, that for miners and ex-miners being 7·5 per 1,000 Table 3. Such a finding is consistent with the view that silica dust, when inhaled, decreases the resistance to tuberculosis (Vorwald and Delahant, 1938).

The incidence of tuberculosis amongst working quarrymen is also higher than that found in any other industry in routine surveys carried out by the Welsh Mass Radiography Service.

PART II: SURVEY OF QUARRYING COMMUNITIES

To establish the prevalence of pulmonary tuberculosis amongst ex-quarry workers and males not engaged in quarrying living in the quarrying towns and villages, it was necessary to carry out " total community " surveys of the Rhondda Fach type (Cochrane *et al.*, 1952). Three population areas were selected in the largest of the quarrying communities within the Gwyrfai Rural District, *viz.*, Llanberis, Deiniolen, and Pen-y-Groes. Many quarry workers live in smaller communities scattered on the mountain sides, but it was considered that the three population centres chosen would give the information required and would lend themselves well to the " total community " technique.

Definition of the Three Communities Surveyed

Arbitrary decisions were taken when defining the geographical extent and limits of the populations to be surveyed. This is unavoidable and indeed imperative in work of this kind. In doing so, we were mainly influenced by such factors as topography and the general concentration and distribution of the population. The population (including sex, age, and principal occupation) of the arbitrarily and geographically defined communities was ascertained by a census undertaken by the staff of the unit concerned in the actual radiography. Our figures do not, therefore, agree with any official rural or urban district population.

Results

Table 6a shows the response obtained in the three towns and Table 6b analyses this response according to age, sex, and occupation.

The figures in these tables show the response obtained from the various sections of the three communities. Whilst not as satisfactory as the 90%

TABLE 6a

ANALYSIS OF RESPONSE TO MASS RADIOGRAPHY SURVEYS IN THREE QUARRYING TOWNS

	Llanberis	Deiniolen	Pen-y-Groes	Total
Population	1,883	1,251	1,612	4,746
Number radiographed	1,437	978	1,158	3,573
Number failing to attend	446	273	454	1,173
Percentage of population radiographed	76·31	78·18	71·84	75.28

TABLE 6b

ANALYSIS OF RESPONSE TO MASS RADIOGRAPHY IN THREE QUARRYING TOWNS ACCORDING TO AGE, SEX, AND PRINCIPAL OCCUPATIONAL GROUP

	Total	Age Group (years)															
		0–4	5–9	10–14	15–19	20–24	25–29	30–34	35–39	40–44	45–49	50–54	55–59	60–64	65–69	70–74	75 +
Male population																	
Non-quarrymen radiographed	1,094	69	196	183	106	55	58	65	57	56	60	68	45	29	23	15	9
Non-quarrymen failing to attend	458	35	5	10	21	21	38	32	27	59	36	36	32	23	26	29	28
Quarrymen radiographed	482	—	—	—	41	34	41	58	27	60	71	59	36	26	16	11	2
Quarrymen failing to attend	59	—	—	—	1	3	2	6	3	6	11	9	7	7	3	1	—
Ex-quarrymen radiographed	136	—	—	—	1	1	2	6	6	10	12	6	12	10	14	30	26
Ex-quarrymen failing to attend	29	—	—	—	—	—	1	—	—	1	1	1	1	1	6	5	11
Totals	2,258	104	201	193	170	114	142	167	121	192	191	179	133	96	88	91	76
Failed to attend (%)	24·2	33·7	2·5	5·2	12·9	21·1	28·9	22·8	25·6	34·4	25·1	25·7	30·1	32·3	39·8	38·5	51·3
Female population																	
No. radiographed	1,861	65	195	171	124	117	131	132	131	146	141	157	106	88	68	58	31
Failed to attend	627	21	5	5	24	28	33	27	23	60	51	48	47	48	56	62	89
Totals	2,488	86	200	176	148	145	164	159	154	206	192	205	153	136	124	120	120
Failed to attend (%)	25·2	24·4	2·5	28·4	16·2	19·3	20·1	17·0	14·9	29·1	26·6	23·4	30·7	35·3	45·2	51·7	74·2
Grand Totals	4,746	190	401	369	318	259	306	326	275	398	383	384	286	232	212	211	196

response obtained in the Rhondda Fach, the response was high enough for comparison to be made with the findings of the Rhondda survey (Cochrane *et al.*, 1952), subject to certain reservations.

Prevalence of Pulmonary Tuberculosis.—To attempt an assessment of the prevalence of active pulmonary tuberculosis, a list was obtained from the chest clinic of those still on the " live " register of tuberculous persons living in the populations previously described and still considered to be suffering from active pulmonary tuberculosis. This list was checked with those kept by the County Medical Officer, and to it were added those persons found to be suffering from active tuberculosis as a result of the quarry survey who lived in the defined area, and those found to be suffering from active tuberculosis during the total community surveys who were not previously known. All these are included in those radiographed in Tables 6a and 6b.

The prevalence of pulmonary tuberculosis amongst those not radiographed is likely to be at least as great, if not greater, than amongst those radiographed, and it is for this reason that the prevalence rates are based on the number of persons radiographed and not on the total population figures for the three communities. These rates are, therefore, comparable with those found for active cases in the Rhondda Fach survey. Fig. 1 and Table 7 show the prevalence of active pulmonary tuberculosis (including infectious) by age, sex, and occupation for the three quarrying communities.

Comparison with the Rhondda Fach Survey.—The findings for prevalence of infectious and active pulmonary tuberculosis in certain groups compared with findings for similar groups in the Rhondda Fach are of interest.

Quarrymen and Ex-quarrymen.—Six hundred and eighteen quarry and ex-quarry workers were radiographed and 11 infectious and 26 non-infectious cases of active pulmonary tuberculosis were discovered.

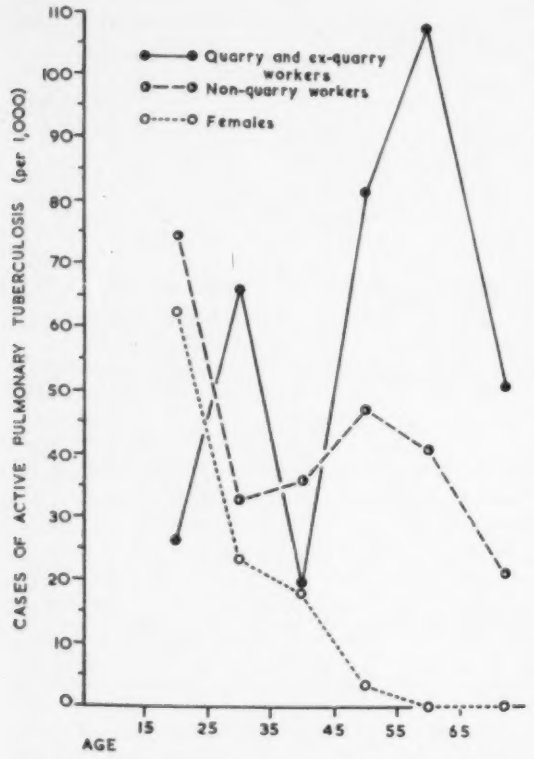

FIG. 1.—Prevalence of active pulmonary tuberculosis (including infectious) by age, sex, and occupation in three "quarrying" communities (or towns).

This gives a rate of 17·8 infectious cases per 1,000 radiographed, as compared with 5·3 per 1,000 amongst miners and ex-miners radiographed in the Rhondda Fach, and a rate of 60 per 1,000 for all active cases in this group as compared with 7·5 per 1,000 for the Rhondda Fach (Fig. 2 and Tables 7 and 8).

Men not Engaged in Quarrying.—Amongst 646 non-slate male workers over the age of 15 radiographed in the three towns in the Gwyrfai Rural District, there were nine infectious and 21 non-infectious cases of pulmonary tuberculosis—a rate of 46·4 active cases per 1,000 radiographed compared with 13·5 per 1,000 for non-mining males in the same age group in the Rhondda Fach (Figs. 3 and 4, and Tables 7 and 8).

Females.—Amongst 1,430 females over the age of 15 radiographed in the three towns in the Gwyrfai Rural District, there were two infectious and 25 non-infectious cases of active pulmonary tuberculosis, a prevalence rate of 18·9 per 1,000 radiographed for all active cases as compared with 10·7 per 1,000 radiographed in the Rhondda Fach (Fig. 5 and Table 7).

Pneumoconiosis.—The purpose of the community survey was, primarily, to ascertain the prevalence of active pulmonary tuberculosis in the population of the three towns by age, sex, and principal occupation. The findings relative to pneumoconiosis are of less interest except perhaps where progressive massive fibrosis is concerned.

Amongst the 618 quarry and ex-quarry workers radiographed there were 123 cases of pneumoconiosis of category 2 and over, including 65 cases of P.M.F. (Table 9), a rate for P.M.F. of 105 per 1,000 compared with 129 per 1,000 in the Rhondda Fach.

All of these P.M.F. cases were asked to attend for an interview but less than half came. Laryngeal swabs were taken and sputum specimens obtained

TABLE 7

PREVALENCE OF ACTIVE (INCLUDING INFECTIOUS) CASES OF PULMONARY TUBERCULOSIS IN THREE QUARRYING TOWNS BY AGE, SEX, AND OCCUPATION

Age Group	Total Population Radiographed	Females				Male Quarry and Ex-quarry Workers				Male Non-quarry Workers			
		Number Radiographed	Number of Active Cases		Active Cases per 1,000	Number Radiographed	Number of Active Cases		Active Cases per 1,000	Number Radiographed	Number of Active Cases		Active Cases per 1,000
			Sputum +ve	Sputum —ve			Sputum +ve	Sputum —ve			Sputum +ve	Sputum —ve	
15–24	479	241	2	13	62·2	77	2		26·0	161	3	9	74·5
25–34	493	263		6	22·8	107	2	5	65·4	123		4	32·5
35–44	493	277		5	18·1	103	1	1	19·4	113	1	3	35·4
45–54	574	298		1	3·4	148		12	81·1	128	3	3	46·9
55–64	352	194				84	4	5	107·1	74	2	1	40·5
65+	303	157				99	2	3	50·5	47		1	21·3
	2,694	1,430	2	25	18·9	618	11	26	59·9	646	9	21	46·4
0–15	879	431		1	2·3					448		7	15·6
	3,573	1,861	2	26	15·1	618	11	26	59·9	1,094	9	28	33·8

TABLE 8

PREVALENCE OF INFECTIOUS PULMONARY TUBERCULOSIS IN MALES IN THREE QUARRYING TOWNS BY AGE AND OCCUPATION

Age Group (years)	Quarry and Ex-quarry Workers			Non-quarry Workers			Total Males		
	Number Radio-graphed	Number of Infectious Cases	Infectious Cases per 1,000	Number Radio-graphed	Number of Infectious Cases	Infectious Cases per 1,000	Number Radio-graphed	Number of Infectious Cases	Infectious Cases per 1,000
15–24	77	2	26·0	161	3	18·6	238	5	21·0
25–34	107	2	18·7	123	—	—	230	2	8·7
35–44	103	1	9·7	113	1	8·9	216	2	9·3
45–54	148	—	—	128	3	23·4	276	3	10·9
55–64	84	4	47·6	74	2	27·0	158	6	38·0
65+	99	2	20·2	47	—	—	146	2	13·7
	618	11	17·8	646	9	13·9	1,264	20	15·8

from the 28 who attended, and in no case was a positive result obtained. The number of cases tested is, unfortunately, too small to justify drawing any conclusions as to the infectivity of P.M.F. cases discovered in the survey. It should be noted, however, that of the 37 cases diagnosed at the clinic as suffering from active pulmonary tuberculosis from amongst the 618 quarry and ex-quarry workers, 29 had pneumoconiosis of category 2 or over, and eight of these had a positive sputum, including three cases of P.M.F. in ex-quarrymen. This adds weight to the contention made earlier in this paper that laryngeal swabbing and sputum testing done on a single occasion in the field are not sufficiently effective methods of detecting the tubercle bacillus (Table 10).

Discussion

The prevalence rates for both infectious and total active cases of pulmonary tuberculosis amongst males in the quarrying communities are considerably higher than those found in the Rhondda Fach survey. The prevalence rate for P.M.F. is rather lower in the quarrying community.

In assessing the significance of these findings account has to be taken of certain differences between the two surveys. In the survey of quarrying communities small films were used; there was a higher rate of failure to attend and perhaps a less intensive search for the tubercle bacillus was made in doubtful cases than was possible in the research project in the Rhondda. All these differences tended to minimize the rates for active and infectious cases in the quarrying community. Thus it is highly probable that the true differences are really greater than indicated by the figures in this paper.

There is also the difficulty of separating P.M.F. from tuberculosis and deciding on the degree of activity from the radiograph. This is even more difficult in the type of film seen among the quarrymen

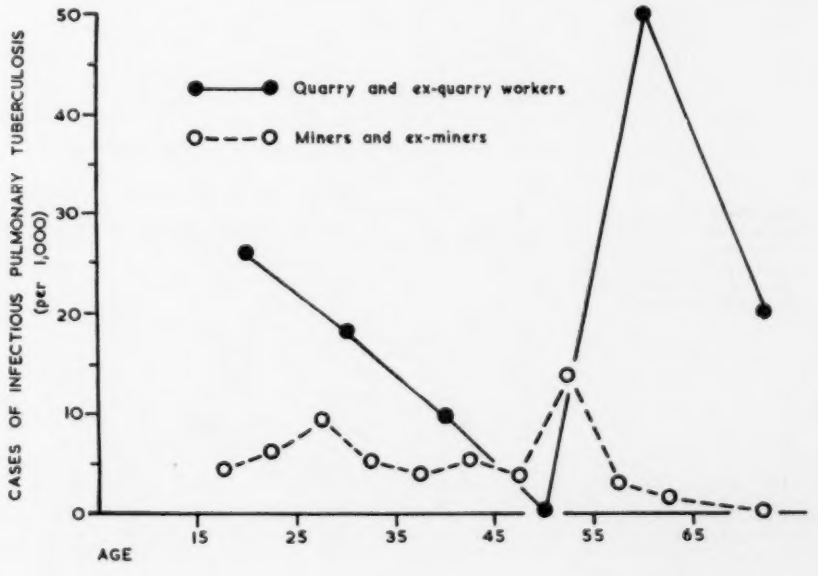

FIG. 2.—Prevalence of infectious pulmonary tuberculosis in quarry and ex-quarry workers compared with miners and ex-miners in a coal-mining valley.

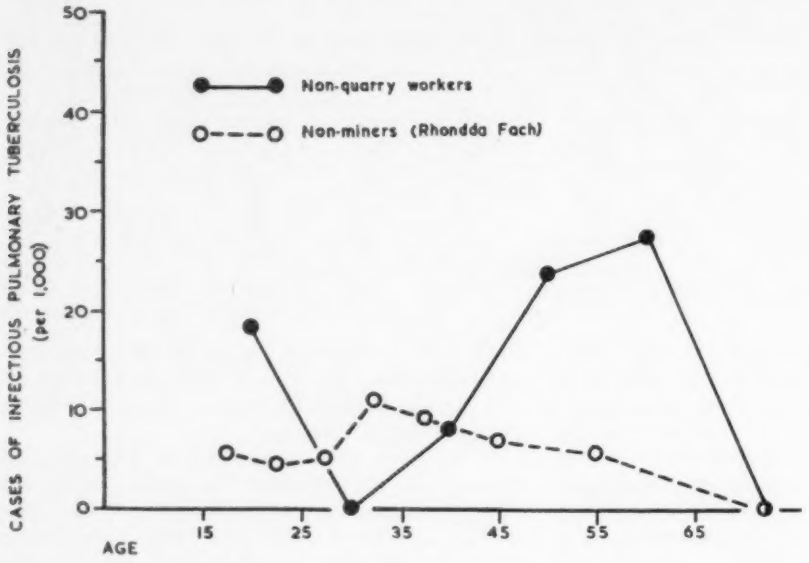

FIG. 3.—Prevalence of infectious pulmonary tuberculosis in workers not engaged in quarrying compared with that in non-miners in a coal-mining valley.

than in the miners. When a composite rate for infectious and non-infectious pulmonary tuberculosis and P.M.F. is calculated (Table 11) the rate for the quarrying community (165 per 1,000) is again higher than that for the mining community (136 per 1,000).

It is somewhat surprising and of considerable interest and importance that the prevalence of active cases amongst the males not engaged in quarrying should be so high when compared with the Rhondda Fach (Tables 7 and 11). This makes it almost impossible to answer with certainty the question, Is the quarrying industry responsible for the high prevalence rates for active cases of pulmonary tuberculosis in the Gwyrfai district ? It may be that the pneumoconiosis of quarry workers increases their risk so far as pulmonary tuberculosis is concerned, but this has not been proved by this survey. Nevertheless, the very high prevalence rate of 60 active cases per 1,000 examined amongst the quarry and ex-quarry workers does suggest that their occupation is an important factor in determining

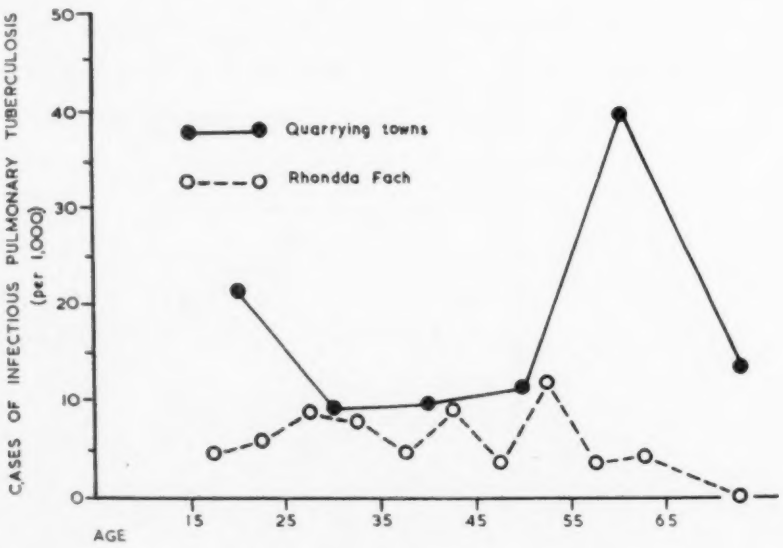

FIG. 4.—Prevalence of infectious pulmonary tuberculosis in all workers in three quarrying towns compared with that in all workers in a coal-mining valley.

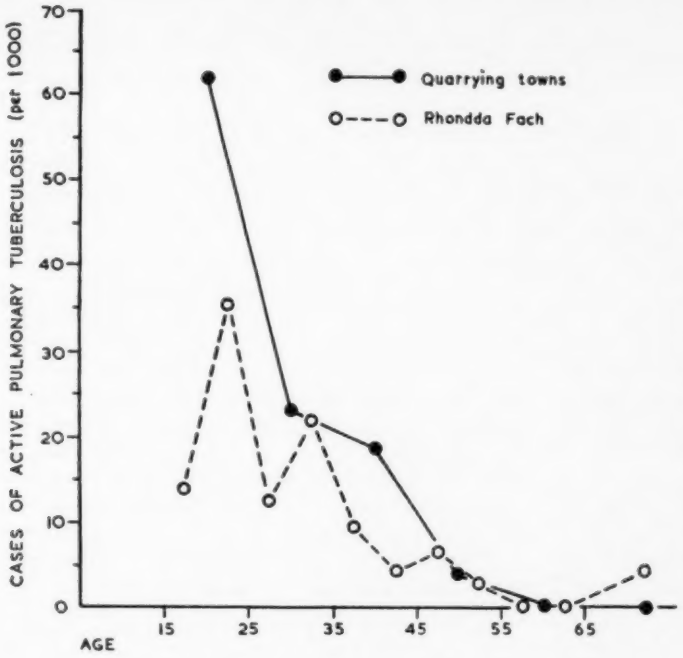

FIG. 5.—Prevalence of active pulmonary tuberculosis (including infectious) in females in three quarrying towns compared with that in females living in a coal-mining valley.

this rate. The prevalence for all infectious cases of at least 18 per 1,000 examined suggests that this may be an important source of infection for the male population, especially when the gregarious habits of the older age groups of this section of the community are taken into account. It is clear, also, that the male population of the quarrying communities is, as a whole, at special risk so far as pulmonary tuberculosis is concerned. The female population is, however (except for the age group 15-25), at only slightly greater risk than that in the Rhondda Fach.

TABLE 9

PNEUMOCONIOSIS IN 618 QUARRY AND EX-QUARRY WORKERS IN THREE QUARRYING TOWNS

Age Groups (years)	Category of Pneumoconiosis										Total
	0		1		2		3		P.M.F.		
	Quarry Workers	Ex-quarry Workers	Quarry Workers	Ex-quarry Workers	Quarry Workers	Ex-quarry Workers	Quarry Workers	Ex-quarry Workers	Quarry Workers	Ex-quarry Workers	
15–24	75	2	—	—	—	—	—	—	—	—	77
25–34	98	8	1	—	—	—	—	—	—	—	107
35–44	79	13	1	—	6	2	—	—	1	1	103
45–54	105	12	6	2	9	2	3	—	7	2	148
55–64	32	12	6	—	8	2	5	3	11	5	84
65+	17	25	1	—	3	1	1	13	7	31	99
	406	72	15	2	26	7	9	16	26	39	
Totals	478		17		33		25		65		618

TABLE 10

ANALYSIS OF 37 CASES OF ACTIVE PULMONARY TUBERCULOSIS IN 618 QUARRY AND EX-QUARRY WORKERS BY CATEGORY OF PNEUMOCONIOSIS AND SPUTUM STATE

Age (years)	Category of Pneumoconiosis										Total
	0		1		2		3		P.M.F.		
	Sputum +ve	Sputum —ve	Sputum +ve	Sputum —ve	Sputum +ve	Sputum —ve	Sputum +ve	Sputum —ve	Sputum +ve	Sputum —ve	
15–24	2	–	–	–	–	–	–	–	–	–	2
25–34	1	4	–	–	1	1	–	–	–	–	7
35–44	–	–	–	–	–	1	1	–	–	–	2
45–54*	–	1	–	–	–	6	–	5	–	–	12
55–64	–	–	–	–	2	4	1	1	1	–	9
65+	–	–	–	–	–	2	–	1	2	–	5
Totals	3	5	–	–	3	14	2	7	3	–	37

* Of the 12 cases in age group 45–54 who were originally sputum negative, six became sputum positive after January, 1955. This would alter Fig. 2 as the prevalence of infectious pulmonary tuberculosis in quarry and ex-quarry workers would be much higher at all ages than in miners and ex-miners.

TABLE II

COMPARISON OF PREVALENCE OF TUBERCULOSIS AND COMPLICATED PNEUMOCONIOSIS AMONG QUARRYMEN AND EX-QUARRYMEN AND MINERS AND EX-MINERS

Groups	Radiographed	(1) Infectious Tuberculosis	(2) Non-infectious Tuberculosis	(3) P.M.F.	Total (1), (2), (3)
Quarrymen and ex-quarrymen	618	11 (17·8)*	26 (42·1)	65 (105·2)	102 (165)
Miners and ex-miners (Rhondda Fach, 1951)	6,026	32 (5·3)	13 (2·2)	776 (128·8)	821 (136)

* Figures in parentheses indicate rates per 1,000 examined.

SUMMARY

Part I

Two thousand four hundred and thirty-two working quarrymen from five slate quarries in Caernarvonshire were radiographed using 70 mm. films. This represents 90% of all the workers at these quarries.

The prevalence of pneumoconiosis of category 2 and upwards was 83 per 1,000 examined amongst working quarrymen; in the Rhondda Fach the rate for miners and ex-miners was about 300 per 1,000 examined.

The prevalence of infectious tuberculosis amongst the working quarrymen examined was 5·3 per 1,000 examined in contrast to the lower rate for working miners in the Rhondda Fach of 1·4 per 1,000 examined.

Active and infectious pulmonary tuberculosis is a more serious problem than simple pneumoconiosis in this group of the industry.

Part II

Seventy-five per cent. of the population of three slate-quarrying towns in the Gwyrfai Rural District of North Wales were radiographed. Prevalence rates for active pulmonary tuberculosis amongst quarry and ex-quarry workers, males not engaged in quarrying, and females, based on this survey and subsequent diagnostic follow-up at the chest clinic, are presented and comparisons made with findings in similar groups in the Rhondda Fach in South Wales.

The prevalence of infectious cases amongst quarry and ex-quarry workers was 17·8 per 1,000 radiographed as compared with 5·3 per 1,000 amongst miners and ex-miners in the Rhondda Fach, and a rate of 60 per 1,000 for all active cases (including infectious) in this group compared with 7·5 per 1,000 for the Rhondda Fach. The prevalence rate for all active cases of tuberculosis amongst males not engaged in quarrying was 46·4 per 1,000 radiographed compared with 13·5 per 1,000 for males not engaged in mining in the Rhondda Fach. The prevalence rate for active cases amongst females, over the age of 15, was 18·9 per 1,000 radiographed compared with 10·7 per 1,000 in the Rhondda Fach.

It would appear that quarriers and males not engaged in quarrying living in quarrying communities are at considerably greater risk of contracting pulmonary tuberculosis than miners and males not engaged in mining in a coal-mining valley. Though it has not been definitely proved that the pneumoconiosis of quarry workers is responsible for this, the findings do suggest that working in the slate quarries may be an important contributory and perhaps a major determining factor.

Our thanks are due in the first place to the radiography teams who carried out enthusiastically duties which were by no means always those of a routine mass radiography nature; to Drs. J. C. Gilson, A. L. Cochrane, and W. E. Miall, of the Medical Research Council's Pneumoconiosis Research Unit, for very generous advice, criticism, and help in the preparation of this paper; to Dr. J. Marks, of the Central Tuberculosis Laboratory, Cardiff, for the bacteriological work; and to Mr. Fred Moore for the preparation of the graphs.

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AN OUTBREAK OF WEAVER'S COUGH ASSOCIATED WITH TAMARIND SEED POWDER

BY

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(RECEIVED FOR PUBLICATION, JANUARY 28, 1957)

Several cases of respiratory disease, varying in severity from a dry cough to severe bronchospasm, have recently occurred in a few British textile factories. They appear to be connected with the use of ground tamarind seed as a sizing agent. Although the seed had been used extensively in India for this purpose, no untoward effects on health had been reported but shortly after its introduction into Great Britain cases began to appear. The worst effects were seen in certain weavers handling rayon but there were some cases also in those concerned with cutting the cotton velvet.

Sizing and Weaving

The application of a size to the warp threads is a necessary preliminary to weaving in order to give the yarn power to withstand the friction in the loom. In the past several substances have been used, usually of a starchy character. Sago, farina, maize, potato starch, and carob flour (locust bean gum) are commonly used materials but research is constantly going on to discover better sizing agents. Improvements in finishing, such as crease resistance, very often depend upon the size used and the ease and completeness of its removal.

About one twentieth of the size applied leaves the warp during weaving. An unknown quantity remains suspended in the atmosphere but most falls on the floor, together with short fibre, forming a fluffy deposit called, in north-east Lancashire, " dawn ".

Previous Outbreaks of Weaver's Cough

In 1913 Collis described an outbreak of an unusual cough among weavers in north-east Lancashire. The condition was associated with constriction of the chest, an irritating cough, purulent sputum, dyspnoea on effort, and asthmatic attacks. The material woven was cotton, sized with a mixture of flour (derived from wheat, sago, or potatoes), tallow, china clay, and water without any preservative. Just before the onset of the illness the warp threads developed a mildew while on the looms. When dry threads were substituted the symptoms disappeared. A recurrence of mildew on the yarn led to a reappearance of symptoms. In another mill where there was a sharp division of mildewed and unaffected warps only the weavers working on the former became affected. Collis concluded that the illness was due to mildew and compared the condition to that of aspergillosis.

Bridge (1924) and Middleton (1926) described similar attacks of weaver's cough due to mildew.

Vigliani, Parmeggiani, and Sassi (1954) described an epidemic of bronchial asthma among the weavers of a large cotton factory. In this instance the cotton yarn was sized with carob flour and potato starch. Fifty per cent. of the weavers had been affected with a dry cough, scanty sputum, dyspnoea, and rasping in the throat. Symptoms were worse on Mondays. On examination 105 weavers were affected with bronchial asthma, 27 of them severely. In the slight cases the attacks lasted for two or three months while the more severe cases lasted for five to six months. It was assumed that the epidemic was similar in origin to those described by Collis but investigations carried out towards the end of the epidemic did not disclose any particular abundance of moulds. Indeed, the atmospheric contamination of bacteria and fungi was greater in the spinning and weaving preparation departments, which were not affected by the epidemic. Skin tests with mould extracts were negative except for *Aerobacter aerogenes* which gave a positive reaction in 46% of the controls, in 76% of the moderate and slight cases, and in 100% of those severely affected. The organism, however, was either very scarce or absent in samples of the yarn and dust from the weaving department.

* Robert Murray was formerly H.M. Medical Inspector of Factories, Manchester.

It was considered that as the bacteriological and immunological investigations had been delayed until the epidemic was abating no conclusions could be reached concerning the cause of the epidemic.

One other outbreak in which workers exposed to vegetable dust suffered acute respiratory symptoms is worthy of mention. This was reported by Hunter and Perry (1946) and occurred in workers with crushed sugar cane after extraction of the sugar (bagasse). Symptoms usually began after eight weeks' exposure. The attack began with an acute febrile illness, extreme shortness of breath, cough, and scanty, black, stringy sputum. Chest radiography showed temporary miliary shadows and the whole picture suggested an acute bronchiolitis which usually cleared in about six weeks. This condition was not considered by Hunter to be a true pulmonary mycosis.

The Present Outbreak

The factory most severely affected in the present outbreak was a large weaving shed containing 1,200 belt-driven Lancashire looms. Ventilation was provided by a few opening lights in each bay of the saw-toothed roof and a row of small extractor fans along one wall. There was no air-conditioning or artificial humidification. The cubic space per individual, excluding machinery, was of the order of 1,000 cubic feet.

In January, 1956, an unusually high sickness absence rate became apparent, much in excess of that experienced during January, 1955, or 1954. This was in marked contrast to a neighbouring weaving shed, of similar type, where the size used was locust bean gum. The excess in sickness absence increased further during February and March and there was no sign of a decline until the end of May. This occurrence could not be attributed to any general epidemic or to adverse weather conditions. Indeed, meteorological observations in the area indicated that it had been a particularly mild March and April and many chronic bronchitics working in the factory said that it had been their best winter for some years.

The firm had begun using tamarind size in October, 1955. Initially only three warps were sized but the results were so encouraging that 20 warps were treated. With continued good results all spun rayon warps were sized with tamarind.

The extent of the use was as follows:—

	Bags of 100 lb.	Warps
October, 1955	12	72
January, 1956	12	72
February, 1956	54	324
March (part), 1956	28	168
	106	636

By the middle of March complaints of coughing among the weavers became so clamant that the size, as the only new material in use, was suspected as the cause of the trouble and its use ceased. By that time a total of 636 warps had been sized with tamarind. The warp may not get into the loom for two to three weeks after sizing and it remains there for four to five weeks so that any risk inherent in the material would be prolonged beyond the date at which sizing ceased until six to eight weeks later. In fact, this time was lengthened because so many weavers were off sick.

There were 180 men and 208 women working in the weaving shed, but 16 of them were excluded from consideration for the following reasons:—

	Men	Women
Intermittent, vague, or very slight exposure	6	3
Clinical condition (1 hypertension, 1 ? neoplasm, 1 ? coronary)	1	2
Absent throughout relevant period	1	3

Their occupations were as follows:—

Occupation	Men	Women
Weavers	73	144
Overlookers	21	—
Winders—unsized weft only	—	38
Warehousemen	12	—
Cloth lookers	10	—
Warp pinners	—	11
Others	64	15
Total	180	208

Thirteen of the men (five weavers, three overlookers, and five others) had been working with nylon and terylene in a separate department and had not been directly exposed to any hazard from tamarind size. The 38 winders and two women in other occupations had similarly not been exposed. It was therefore possible to compare the incidence and type of sickness of the two groups, those who had been directly exposed to tamarind and those who had not been so exposed.

Details of sickness absences were supplied by the firm. The total population of 388 men and women were interviewed individually. Information was thus obtained of previous illnesses and of any symptoms which had occurred during the past six months. It was found that, during the period January 1, 1956, to May 14, 1956, there had been a highly significant excess of absenteeism (Table 1) among the exposed women ($P < 0{\cdot}001$, $\chi^2 = 19$). Too few men had not been exposed to be able to make any valid comparison.

There was no evidence that this excess of absenteeism could be attributed to a difference in age distribution. Although the mean age of the

TABLE 1

ABSENCE IN MEN AND WOMEN EXPOSED AND NOT EXPOSED TO TAMARIND HAZARD FROM JANUARY TO MAY, 1956

	Men		Women	
	Absent	Not	Absent	Not
Exposed	51	116	106	62
Not exposed	4	9	10	30
Total	55	125	116	92

exposed women (39·3 years, standard error 1·0) was slightly greater than that of the unexposed (36·6 years, standard error 1·7) the difference was not significant.

The reasons given for absence were examined and are shown in Table 2.

TABLE 2

CAUSE OF ABSENCE AND EXPOSURE

Cause of Absence	Men		Women	
	Exposed (167)	Not Exposed (13)	Exposed (168)	Not Exposed (40)
Cough and/or breathlessness	32	1	71	1
" Influenza "	3	–	6	3
Throat infection	2	1	3	–
Non-respiratory diseases	7	–	9	3
Injuries	4	–	6	–
Domestic duties	1	2	9	2
Other	2	–	2	1
Total	51	4	106	10

The two groups of women show a similar incidence of domestic duties (5% and 2/40) and non-respiratory disease (7% and 3/40) as reasons for absence. The very large total difference is mainly due to absences attributed to cough and/or breathlessness. When this category is combined with " influenza " (of which there is a slight increase among the unexposed) the resulting excess among the exposed is highly significant ($P < ·001$, $\chi^2 = 17$).

There was no evidence that sickness absence during this period was influenced by a history of a previous chest illness (Table 3).

TABLE 3

MEDICAL HISTORY AND ABSENCE

Medical History	Men		Women	
	Absent	Not Absent	Absent	Not Absent
Chest illness	16	33	39	30
Nothing relevant	39	92	77	62

It was therefore apparent that the women who had been exposed to a direct hazard from tamarind size, primarily weavers, had had a sickness experience during the period January to mid May which was fundamentally different from that of the women, primarily winders, who had not been so exposed, a difference which it was difficult to attribute to any cause other than occupation, and which had resulted in symptoms of cough and/or breathlessness.

Of all those who had been exposed, 106 men (63%*) and 141 women (84%) were considered to have been affected. The symptoms ranged from a dry, throaty cough to an acute and severe respiratory distress. The effect was not produced on first exposure, a minimum period of at least two weeks appearing to be required for sensitization. Cough, dyspnoea, and purulent sputum were the most frequent complaints (Table 4). A greater proportion of women complained of irritation of the eyes ($P < 0·05 > 0·01$, $\chi^2 = 6·3$), a difference possibly due to occupation as 12 of the 14 men similarly affected were weavers.

TABLE 4

FREQUENCY OF SYMPTOMS

Symptom	Men (106)		Women (141)	
	No.	(%)	No.	(%)
Cough	95	90	135	96
Sputum				
Purulent	72	68	83	59
Other	15	14	21	15
Dyspnoea	72	68	100	71
Chest tightness	68	64	81	57
Irritation of throat	52	49	77	55
Wheezing	39	37	59	42
Irritation of eyes	14	13	37	26
Other	27	25	54	38

Age did not appear to have influenced the chances of a woman becoming affected. The mean ages of those who had and had not suffered any ill-effects were 39·3 years (standard error 1·1) and 39·0 years (standard error 2·8) respectively.

The men showed rather a different picture. There appeared to be a greater propensity to succumb as age increased (Table 5). This finding can be partly accounted for by the fact that the most susceptible group, weavers, were older than the remainder. There was, nevertheless, a substantial difference in the ages of both weavers and others who had and had not been affected.

TABLE 5

AGE, OCCUPATION AND AFFECTION OF MEN EXPOSED TO TAMARIND

Occupation	Affected	No. in Group	Mean Age (years)	Standard Error
Weavers	No	9	35·5	5·5
	Yes	59	48·3	1·4
Others	No	52	40·1	1·8
	Yes	47	49·4	1·9

* Fifty-nine (87%) male weavers were affected compared with 63% of all exposed men, a significant excess ($P < ·001$, $\chi^2 = 27$).

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Symptom	Men (106)		Women (141)	
	No.	(%)	No.	(%)
Cough	95	90	135	96
Sputum				
Purulent	72	68	83	59
Other	15	14	21	15
Dyspnoea	72	68	100	71
Chest tightness	68	64	81	57
Irritation of throat	52	49	77	55
Wheezing	39	37	59	42
Irritation of eyes	14	13	37	26
Other	27	25	54	38

Age did not appear to have influenced the chances of a woman becoming affected. The mean ages of those who had and had not suffered any ill-effects were 39·3 years (standard error 1·1) and 39·0 years (standard error 2·8) respectively.

The men showed rather a different picture. There appeared to be a greater propensity to succumb as age increased (Table 5). This finding can be partly accounted for by the fact that the most susceptible group, weavers, were older than the remainder. There was, nevertheless, a substantial difference in the ages of both weavers and others who had and had not been affected.

TABLE 5

AGE, OCCUPATION AND AFFECTION OF MEN EXPOSED TO TAMARIND

Occupation	Affected	No. in Group	Mean Age (years)	Standard Error
Weavers	No	9	35·5	5·5
	Yes	59	48·3	1·4
Others	No	52	40·1	1·8
	Yes	47	49·4	1·9

* Fifty-nine (87%) male weavers were affected compared with 63% of all exposed men, a significant excess ($P < ·001$, $\chi^2 = 27$).

A history of a previous respiratory illness or a history of allergy did not appear to have any bearing on whether or not either men or women became affected (Table 6).

TABLE 6
MEDICAL HISTORY AND AFFECTION OF WORKERS EXPOSED TO TAMARIND

Medical History	Men		Women	
	Affected (106)	Not Affected (61)	Affected (141)	Not Affected (27)
Previous chest illness	29	15	47	12
Allergic history	5	2	5	3

A feature of the condition was a history of returning to work after sickness absence and finding the symptoms recurred as badly as ever within one to four hours. Some people made three or more attempts to return and each time they became acutely distressed within a short period, although they had been feeling quite fit for some time beforehand and again recovered soon after they had left the factory. Indeed, in all cases removal from exposure resulted in dramatic improvement.

The following are some typical case histories:—

Mrs. T., aged 46, had been a weaver all her working life and except for an occasional cold had never had any illness. In March, 1956, she developed over three weeks a hard, dry cough with a very thick spit in the mornings. She felt hot and feverish and went to bed for two days after which she felt better but still a little weak. A week later she started work and was seen after two hours in the mill to be having difficulty in breathing. She complained again of cough and a burning sensation in the front of the chest.

Mrs. F. McC., aged 54, a weaver all her working life, had never had any chest trouble until the end of February, 1956, when she developed a headache, fullness in the nose, and a hard cough. She took two days off but on her return felt short of breath, particularly at night to such a degree as to feel frightened. On three occasions when her symptoms had disappeared after two to three days at home she returned to work to find that after about two hours she was as bad as ever.

Mrs. D. M., aged 46, a weaver all her working life, had never had more than an occasional cough until early in March, 1956, when gradually over 10 days she developed an irritating cough with a viscid sputum, tightness of the chest, and difficulty in walking up a slope. She stayed off work and felt better after two or three days but on returning at the end of a week she felt a stuffiness in her nose and had a shivering attack. The cough returned, associated with more copious purulent sputum, and spasmodic in character. Smoking made it much worse. After a further week off she returned and was seen after two hours with cough, tightness of the chest, and severe dyspnoea.

Mr. S. F., aged 47, a loom overlooker, had good health up to the beginning of March, 1956, when he developed a cough, with dryness of the throat and tightness of the chest. He became so short of breath that he had to take a bus home instead of walking as he usually did. The cough was worse in the mornings and was associated with a scanty thick spit at first, which became more copious later. After two weeks off work he returned but on the second day was as bad as ever. This time he also lost his voice.

Mr. J. W. P., aged 53, a weaver all his working life and a champion swimmer, had never had a chest illness until Christmas, 1956, when he began to get spasms of coughing. These became worse and were associated with a sore throat, thick spit, tightness of the chest, and difficulty in taking a deep breath. The attacks tended to be worse on Mondays but remained throughout the week. They were similar to the effect of inhaling chlorine. He lost 14 lb. in 12 weeks.

Experiences in Other Factories

Investigations were made at two other factories weaving spun rayon. In the first factory, 45 people had been exposed to tamarind size, of whom 43 were questioned. It was apparent that the numbers affected and the pattern of symptoms were very similar to the findings in the original group.

TABLE 7
NUMBERS AFFECTED IN OTHER FACTORIES

	Men (26)		Women (17)	
	Affected	Not Affected	Affected	Not Affected
Weavers	9	2	14	3
Others	7	8	—	—
Total	16	10	14	3

The third factory had been somewhat less affected, but several similar cases had occurred.

Velvet Cutting

In the manufacture of cotton velvet a special type of cloth is woven. It has a surface composed of a number of tiny loops each of which must be cut to form the characteristic pile. The cloth is first sewn to form an endless loop and then passed through a cutting machine several thousand times, depending on the width of the cloth and the closeness of the loops. At each passage one row of loops is cut by a special knife.

In order to withstand this severe treatment the cloth is sized. The size is made up as for weaving, the rate of application is the same as for spun rayon yarn, and roughly the same amount leaves the cloth during treatment. Although cotton has not the same tendency to " fly " as spun rayon the operation is nevertheless a dusty one.

Investigations were made at three velvet cutting factories. The sickness records of the one firm

showed that there had been a substantial increase in absence during January to April, 1956, over that experienced in 1955. The symptoms of the respiratory illnesses which had occurred in all three were similar to those found in the weaving factories. There appeared to be no doubt that they were attributable to the same cause although the proportion of people affected was less: 16 out of 84, 15 out of 39, and five out of 27 respectively.

Tamarind Powder

Tamarind powder is obtained from the kernel of the seed of the tree, tamarindus indica. In India it has, during the last few years, entirely replaced starch for the sizing of jute and to some extent also of cotton yarns. Its use conserves the food starches and is held to have certain advantages over starch from the weaving and finishing standpoints. This success in India led to an investigation in the United Kingdom.

Several independent analyses have been made of tamarind seed kernel powder. They indicate that the main constituent is a carbohydrate and Sarkar and Mazumdar (1952) concluded that it is probably a glucoside. Assuming that all the nitrogen occurs as protein and the sugars as anhydrosugars, Sarkar and Mazumdar give the approximate composition of tamarind seed kernel powder in Table 8.

TABLE 8

APPROXIMATE COMPOSITION OF T.S.K. POWDER (OVEN-DRY BASIS)

Constituent	Commercial Sample (%)	Laboratory Sample (%)
Glucosan	47·2	49·8
Xylan	20·5	19·7
Protein	17·5	18·8
Fat and wax	8·2	7·5
Mineral matter	2·5	3·4

On the other hand, Savur (1955) states that tamarind seeds contain three distinct polysaccharides, namely, P.1 readily soluble in cold water, P.2 which dissolves after an hour's stirring at 25° to 28° C., and P.3 which dissolves only on boiling. He also states that the oil fraction contains palmitic, stearic, arachidic, behanic, oleic, and linoleic acids, and that sitosterol is present.

Laboratory and mill trials carried out by the British Cotton Industry Research Association demonstrated that tamarind seed kernel powder was a practicable sizing adhesive for spun viscose cloth. It gave a better finished handle than the traditional sizes and the ease of de-sizing (by washing in hot water) was an important advantage.

The powder is mixed with cold water, 10% tallow, and 1% preservative (0·8% sodium silicofluoride and 0·2% beta-naphthol) and boiled for an hour. It is applied at the rate of 9% on the weight of the warp yarn so that each square yard contains approximately 4·5 g. of tamarind seed kernel powder, 0·5 g. tallow, 0·04 g. sodium silicofluoride, and 0·01 g. of beta-naphthol.

Atmospheric and Skin Tests

Towards the end of the outbreak and just before the last tamarind-sized warps were removed Dr. Tuffnell, of the Bacteriology Department, University of Manchester, carried out estimates of bacteria and fungi. No undue concentration was detected in the air of the shed. Viable fungi amounted to only 7 per cu. ft., and viable bacteria to 15 per cu. ft. The species and the low concentration do not suggest that they were a likely factor in the production of the illness.

With the assistance of the importers of tamarind seed kernel powder and the British Cotton Industry Research Association several fractions were prepared and used for intradermal patch and scratch testing. No conclusive results were obtained.

Discussion and Summary

It has been established that an unusual and widespread outbreak of cough and dyspnoea occurred among weavers of viscose yarn, in which tamarind seed kernel powder had been used as a sizing agent. The condition appeared to be a reaction to a constituent of the size.

The preservatives (fungicides) are unlikely to have been responsible. They were originally suspected by the importers and were left out of subsequent deliveries, without any apparent change in effect. A fungus or other organism is also unlikely to have been the activating agent, since fungicides were present in the material which first produced symptoms and no undue concentration of fungi was detected in the atmosphere of the weaving shed.

The presence of purulent sputum in so many cases raises the question of an infective or irritant factor but an allergic reaction is more clearly indicated by the period of sensitization and the fact that those with a previous history of chest disease were not the more severely affected. Negative or equivocal skin reactions are commonly encountered in such cases of allergy.

As the use of the suspected size has now been discontinued confirmation of these hypotheses can only be obtained by inducing a reaction under controlled conditions. In this way various components of the size can be eliminated and such comparative measurements as timed vital capacities and white cell counts might give an indication of the nature of the condition. This work is in progress.

We are very grateful to the workers and employers whose cooperation made this investigation possible. We should especially like to thank Mr. T. Brown and Miss P. Thomson of Glenfield Mill, Nelson, Dr. D. Hill, of the Shirley Institute, and Mr. Shaw, of the Nelson and District Weavers Association.

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Congresses on Occupational Health

XIIth International Congress on Occupational Health

The XIIth International Congress on Occupational Health will be held in Helsinki from July 1 to 6, 1957. The Committee hopes that the Congress will receive the cordial support and attendance of doctors, engineers, chemists interested in occupational medicine and hygiene, research workers and teachers in this field, social insurance workers, industrial and public health nurses, and others. The International Social Security Association will assist in the preparation of the reports concerned with the social aspects of occupational health.

The preliminary programme is divided into (1) Congress subjects, (2) section subjects, (3) reviews, (4) round table, and (5) group meetings. The Congress subjects are:—Industrial noise, evaluation of invalidity, industrial hygiene norms, and cardiacs and work.

There will be an opportunity before and after the Congress for members to visit and acquaint themselves with the organization and operation of occupational medicine and hygiene in other Scandinavian countries. There will be an excursion on July 7 to industrial establishments and hospitals in various parts of Finland.

The official languages of the Congress are English, French, German, and Spanish.

In addition to the general social programme, a special programme will be arranged for the ladies of the Congress.

The Nicolo Castellino prize, value 3,000,000 lire, will be awarded for the first time at the Congress at Helsinki. The award will be made for what, in the opinion of the assessors, is adjudged to be the most outstanding investigation in the field of occupational health by a research worker, who must be under the age of 35 years and is not the holder of a university chair. Details of the competition will be published at an early date by the Directors of the Fund or can be obtained direct from Directors of Nicolo Castellino Prize, The University, Naples, Italy.

To discover the best films in the field of occupational health a film competition will be organized in connexion with the Congress.

Detailed information can be obtained from the Organizing Committee.

The Congress fee for members is £5 . 8s. and for associate members £3 . 12s.

Notification of intention to be present must be made by May 1, 1957. Hotel accommodation cannot be guaranteed after that date.

Details of the preliminary programme and any further information relating to the Congress may be had on application to the Organizing Committee, c/o Työterveyslaitos, Haartmaninkatu 1, Helsinki-Töölö. Chairman, Dr. Leo Noro, and Secretary-General, Dr. Pentti Sumari.

Post-graduate Courses on Advances in Occupational Medicine

From Thursday, August 1, to Thursday, August 15, 1957, the first Latin-American post-graduate course on advances in occupational medicine will be held at Caracas, Venezuela, organized by the American Union of Occupational Medicine.

The American Union has invited the collaboration of well-known European and American authorities on industrial medicine to ensure a high scientific standard. The course can be attended by doctors, industrial engineers, and industrial chemists.

Venezuela's Government has offered lodging at the University's residence and meals prepared by the National Institute of Nutrition at very reasonable prices.

Each participant in the course will receive a special certificate and copies of the proceedings.

The course will be coordinated by Professor Dr. José Pedro Reggi, Argentine, General Director of the American Union of Occupational Medicine.

The Secretary's Office of the American Union of Occupational Medicine, Arenales 981, Buenos Aires, Argentina, will give all the information required.

Brit. J. industr. Med., 1957, **14**, 111.

AN OUTBREAK OF TRI-ORTHO-CRESYL PHOSPHATE (T.O.C.P.) POISONING IN DURBAN

BY

MERVYN SUSSER AND ZENA STEIN

From King Edward VIII Hospital, Durban, South Africa

(RECEIVED FOR PUBLICATION AUGUST 30, 1956)

Tri-ortho-cresyl phosphate (T.O.C.P.) is an organic phosphorus compound commonly used in industry as a plasticizer, and is so used in the manufacture of lacquers, dopes, synthetic fabrics, and synthetic lignin resin; it is used as a water-proofing agent in textile manufacture. It is said to be an excellent grinding medium for pigments; it is also used in making polyvinyl chloride sheeting and for the recovery of phenol residues from gas-plant effluents. The vapour pressure of T.O.C.P. is 0·01 mm. Hg at 20° C. Its solubility in water is less than 0·002 % at 86° C. and even less at lower temperatures, but T.O.C.P. is readily soluble in all common organic solvents, including alcohol, and in most vegetable oils. It is chemically stable and resists hydrolysis.

Previous Outbreaks

Eight previous outbreaks of T.O.C.P. poisoning have been reported. The first was by Lorot (1899) when six cases occurred among patients who were given a phosphocreosote cough mixture which contained T.O.C.P.

The great mass of recorded cases occurred in the United States in 1930 during prohibition. Some 10,000—15,000 people were poisoned by a popular substitute for alcohol called " ginger jake ". It has never been discovered precisely why T.O.C.P. was used in abstracting the Jamaica root that flavoured this ginger extract (Smith, Elvove, and Frazier, 1930; Smith and Elvove, 1931; Smith, Engel, and Stohlman, 1932; Burley, 1930, 1932; Zeligs, 1938; Aring, 1942). Many of these patients were hard drinkers or vagrants in a period of economic depression.

In 1931 several hundred women in Europe were poisoned by T.O.C.P. combined in an apiol pill and taken as an abortifacient. The T.O.C.P. was presumably included as an additional stimulus to abortion (Ter Braak, 1931).

The next report came from Durban in 1938. Thirty-one men, women, and children, including whites, Africans, and Indians, were affected by a " mystery disease ". A further 27 cases then occurred on the French ship Jean L.D., practically rendering her helpless in the Bay of Biscay. This ship had called at Durban. The source was traced to drums of cooking oil contaminated by previous use for T.O.C.P. (Drummond, 1938).

Walthard (1946) described an outbreak in 1940 when 80 men of the Swiss army were poisoned; T.O.C.P. had been mistakenly used as cooking oil.

During the war, when fats were in extremely short supply in Germany, several factory workers took T.O.C.P. home and were poisoned when they used it as a fat substitute in cooking (Humpe, 1942).

Hunter, Perry, and Evans (1944) described three cases in England in 1942. Three men, who worked over a tank containing T.O.C.P. in the closest black-out conditions, were apparently poisoned by vaporization of the T.O.C.P.

Finally Hotston (1946) collected several cases which appeared sporadically in Liverpool; the source was again traced to contaminated cooking oil.

A Recent Outbreak in South Africa

An outbreak occurred in Durban, South Africa, in 1955, involving 11 African patients whose ages ranged from 7 to 46 years.

In addition to the 11 patients, we had the opportunity of examining four others, the mother, father, son, and daughter of one family who had all been poisoned in Durban in 1937-38, 18 years before. This was a white family whose ages in 1955 ranged from 28 to 55.

In July, 1955, D. N. and G. N., a married couple, and R. H., who lived in the same shack, were admitted to King Edward VIII Hospital, Durban. The 14-month-old daughter of D. N. and G. N. was the only other occupant of the shack and she

did not fall ill. R. H. went to a different ward from his room-mates and the connexion between him and the others was not known at that time. A diagnosis of radiculo-myelitis was made in the case of R. H., while D. N. and G. N. were considered to have polyneuritis of unknown aetiology.

D. N. was employed at a local paint factory. From his friends he heard that E. K., a fellow-worker who had been on the same night shift with him, had fallen ill with a similar complaint to his and at about the same time. E. K. never came to hospital but we visited him and he is included in the series.

D. N.'s shack was unoccupied from July until the beginning of October, when relatives moved in. One month later all the new occupants, except a month-old baby, contracted the illness. This group comprised two women, two men, and three children.

The only connexion between D. N. and E. K. was the paint factory. The rest of the patients all occupied D. N.'s home, using the same premises and some of the same utensils and water containers but not the same food.

Apart from the convincing clinical picture (confirmed by Dr. J. Drummond, who had observed and reported on the 1937-38 Durban outbreak), the connexion with T.O.C.P. was made when we learned that this compound was freely used without special precautions in the paint factory at which D. N. and E. K. were employed. No evidence of exposure to any other known poison, including lead, was found.

From this point, investigation became difficult. For obvious reasons, Africans in urban locations have little trust in whites, especially whites who are apparently connected with authority. In this case, suspicion was the more acute because, as was discovered later, not only did D. N. brew illicit liquor for sale, but without permission he and E. K. had removed certain drums from the paint factory. D. N.'s family used these drums for collecting water from the communal tap in the location, for storing water, and for brewing liquor. Water used by the households during July and October was held in these drums. The drums commonly carried T.O.C.P. at the factory from whence they had been removed shortly before D. N. and his household and E. K. fell ill. Tri-ortho-cresyl phosphate was not isolated from the one drum that was found in D. N.'s shack. (It was not isolated from an oil-containing drum at the first attempt in the 1937-38 Durban outbreak.)

The investigation of E. K.'s case could not be undertaken in detail and only limited interviews were held. We are at a loss to explain the escape of the rest of E.K.'s family or indeed the way in which he was poisoned. There was no doubt about the clinical picture in the 11 affected persons, however, and the circumstantial connexion with T.O.C.P. was strong enough evidence that it was the cause of the outbreak.

Mode of Absorption.—Outbreaks of T.O.C.P. poisoning have occurred in several different ways. Both ingestion of the compound—made up in medicaments, or dissolved in alcohol or in vegetable oils—and inhalation have previously occurred. Tri-ortho-cresyl phosphate can also be absorbed through the skin; Hodge and Sterner (1943) on the basis of their experiments with tracers considered this a definite hazard. Although the solubility of T.O.C.P. in water is very low, ingestion with contaminated water in the present episode was probable. Solution in alcohol is unlikely. First, D. N. sold the liquor he brewed and there were no cases amongst his regular customers; secondly, the three children of 11, 9, and 7 years and an adult male, who was an abstainer, all contracted the illness. Hence it must be presumed that the poison was not in the drum used for brewing but in that used for water.

Cooking utensils had been removed and could not be tested. The suspected drums were used for water storage and it seems possible that, despite the low solubility of T.O.C.P., sufficient poison could have been ingested with the water either in solution or in suspension to account for the outbreak. (Cooking in the drums, if this had been the case, would greatly increase the solubility.) This hypothesis compares with the conclusions of Hunter *et al.* (1944) that in spite of the known low vapour pressure of T.O.C.P. poisoning by evaporation did occur in their three cases.

Individual Susceptibility.—Some clinicians report that the severity of the lesion does not appear to be proportional to dosage and it has been suggested that individual susceptibility varies, as the susceptibility of different species certainly does. However, Burley (1932) considered that in his patients dose and effect were related and this agreed with experimental findings. Only a 14-month-old baby in the first group of cases and a 1-month-old baby in the second group escaped poisoning. Young chicks appear to be resistant to the related compound D.F.P. (di-isopropyl-fluorophosphonate) and similarly the babies who escaped poisoning in the present series may have been resistant to T.O.C.P. Perhaps the infant resists demyelination because the long tracts of the spinal cord are not completely myelinated. On the other hand, the babies were to some extent fed separately and may have ingested less water.

TABLE

SYMPTOMS AND SIGNS IN INDIVIDUAL PATIENTS IN AN OUTBREAK OF T.O.C.P. POISONING

Patient			Onset												Upper Limb Affection		Upper Motor Neurone Signs				Total Follow-up Period
No.	Sex	Age	Prodromal Gastro-intestinal Episode	Cramps	Sudden Fall	"Incubation" after Ingestion of T.O.C.P. (days)	Alcohol Habit	Malnutrition (Overt)	Parotid Swelling	Sweating of Extremities	Desquamation of Soles and Palms	Severity (Total)	Sensation, Pain, and Temperature Loss	Flaccid Paralysis	Wasting	Severity	Onset after Start of Illness	Severity	Onset after Start of Illness	Cerebro-spinal Fluid Protein (mg. %)	Time Power First Began to Improve after Onset of Illness	
1.	M	35	—	+	+	?	Mild	—	+	+	—	+ + +	+ (including vibration Sense)	+	+ +	+ +	2 wk.	+ +	2 wk.	80	4 mth.	5 mth.
2.	M	46	—	+	—	?	Mild	—	—	+	—	+ + +	+	+	+ +	+ +	1 wk.	—	—	80	4 mth.	5 mth.
3.	F	35	—	+	+	?	—	—	—	+	—	+ +	+	+	+	+	3 wk.	+	?	60	3 mth.	5 mth.
4.	M	30	—	+	+	21	+ +	+ +	+	+	+	+ + +	+	+	+	+ + +	Onset	—	—	30	—	2 mth.
5.	M	24	—	+	—	14	—	—	+	+	—	+	+ (including posterior columns)	+	+	+	1 wk.	+	4 wk.	Normal	6 wk.	5 mth.
6.	M	7	—	+	—	28	—	+	+	+	—	+ +	+ (very slight)	+	+	+ +	3 wk.	+	2 wk.	Normal	Not known	5 mth.
7.	M	11	—	+	—	21	—	+	+	+	—	+ +	+ (slight)	+	+	+ +	3 wk.	+	2 wk.	30	Not known	5 mth.
8.	F	9	+	+	—	28	—	+	+	+	—	+ +	+ (slight)	+	+	+ +	3 wk.	+	2 wk.	30	4 wk.	2 mth.
9.	F	28	—	+	—	28	+ +	+ +	+	+	+	+	+ (including vibration sense)	+	+	+	2 wk.	—	—	40	4 wk.	Left hospital at three weeks
10.	F	38	—	+	—	33	+ +	+	—	+	—	+ +	+	+	+	+ +	2 wk.	—	—	40	6 wk.	
11.	M	32	—	+	—	?	?	—	—	+	—	+	+	+	+	+	?	+	?	—	3 mth.	5 mth. Never in hospital

(Patients 1, 2, 3 and 11 were first affected in July, the remainder in November, 1955)

Socio-medical Aspects.—At the source of the present outbreak, the paint factory, T.O.C.P. was freely used and available without any understanding of its toxic properties, although the hazards of using T.O.C.P. without adequate precautions can be very grave. In at least two of the previously reported outbreaks, chance contamination of oil containers was responsible.

It was not possible to relate the first group of cases to a common origin. More emphasis on the family and the occupational and social background of the patients might have led to earlier recognition of the syndrome and its epidemic nature. The seven later cases might then have been prevented.

The economic hardship to the family can scarcely be exaggerated. The disease involved all the wage-earners and they are all likely to have had the greatest difficulty in re-establishing themselves in manual labour, almost the only occupation open to them. With the limited resources of an African family after such a set-back rehabilitation is a major problem.

Case Reports of Present Outbreak.—The symptoms and signs of each case are summarized in the Table.

Case 1.—R. H., a man of 35 years, was admitted to hospital on July 15, 1955. Two weeks before admission he fell to the ground suddenly. After this he had difficulty in keeping his balance and noticed cramps in the calves followed by weakness in the limbs. On admission there was complete flaccid paralysis below the ankles, weakness extending up to the hips, and some weakness of the hand grip. Although brisk knee reflexes were found, ankle jerks and plantar responses were absent. Below the knees there was stocking anaesthesia for pain, temperature, light touch, and vibration sense, and hypoaesthesia above the knees as far as the umbilicus. There was very little sensory loss in the hands. The feet were cold and sweating and both parotid glands were diffusely enlarged. After two weeks in hospital a brisk knee jerk with an increase in tone of the quadriceps was detected but complete flaccid paralysis persisted from the ankles down. Gradually, weakness at the wrist increased and the muscles of the calves, the feet, and the intrinsic muscles of the hands wasted away. After about six weeks some hyperaesthesia of the soles appeared, with lessening of the extent of the sensory loss, and four months after admission sensation was almost normal. When last seen by us, five months after admission, there was only moderate improvement in power of the hands, hips, and knees, while complete foot drop persisted. The knee jerk was very brisk and stimulation of the soles produced a total withdrawal of the limb, although the toes and feet were still too weak to show any response. The feet were still sweating but the parotid swelling was gradually subsiding.

Case 2.—D. N., aged 46 years, was one of the men employed in the paint factory from which the poison was presumed to have come. He was admitted to hospital on July 18, 1955, with a history of general weakness,

cramps in the legs, pins and needles, and numbness in the feet and hands for the preceding eight days. He had had difficulty in walking for the five days before admission. On examination, at the ankle power was much reduced, at the knee less so. Some weakness of the small muscles of the hands was found, especially on the right side. Ankle and plantar responses were not obtained. There was anaesthesia distal to the wrists and ankles and hypoaesthesia between knees and ankles. The feet were cold and sweating. There was no parotid swelling.

After two months in hospital the upper limb affection had progressed, so that by then there was complete wrist drop on the right and much weakness on the left. All the intrinsic muscles of the hands were without power and markedly wasted. In the lower limb there was a complete flaccid paralysis below the ankles and weakness extending as far as the hip. Wasting was most marked over the anterior tibial compartment and the vasti. Calf and thigh muscles were tender to pressure, but sensation was otherwise normal. The palms and soles were always cold and moist. Reflexes were normal and equal in the upper limbs, absent at the ankles, and exaggerated at the knees. There was no plantar response at all.

After five months there was a slight increase in power in the proximal muscles of the lower limb.

Case 3.—G. N., the wife of D. N. and the sister of R. H., a woman of 35, was admitted to hospital on July 17, 1955. Ten days earlier, she had suddenly fallen to the ground, and had suffered thereafter from painful cramps in the calves and increasing difficulty in walking. On admission, she was ataxic and had bilateral foot drop. There was no power at all below the ankles, though movements at the hips, knees, and in the upper extremities were normal. The knee jerks were brisk, but no reflexes could be obtained at the ankle and there was no plantar response. There was hypoaesthesia below the calves and anaesthesia of the sole.

After two weeks in hospital, weakness of the hands and wrists was noticed, with hypoalgesia of the thenar borders.

Three months after admission, there was still no power below the ankles, movements at the hip and knee were weaker than average and muscles of the wrist and hand were uniformly weak. The deep reflexes, however, had become exaggerated and the finger flexor test was positive. Ankle jerks were still unobtainable and there was no plantar response. The intrinsic muscles of the hands and of the calf muscles were wasted. The calves were tender to pressure and the palms and soles were sweating. No parotid swelling was observed at any stage.

Case 4.—A. D., a man of 30 years, was a fairly heavy drinker. In the week preceding his admission to hospital, on November 17, 1955, he had had a sudden fall after a drinking bout, followed by cramps in the calves, weakness of the limbs, and a difficulty in keeping his balance. He had also noticed that his face was swollen shortly before admission. On examination, he was hyperpigmented, and had cheilosis and an atrophic, stripped tongue. Both parotids were swollen but not tender. His walk was ataxic and stamping; the extremities were cold and sweating profusely. There was Rombergism, and loss of pain and temperature sense distal to the wrists and ankles. The muscles of the hip joint and of the knee were weak; at the ankles there was a complete flaccid paralysis. Already, at the time of admission, there was weakness at the elbow and no power at the wrist or in the hands. Ankle and plantar reflexes were unobtainable and all other deep reflexes were depressed. We followed up this patient for two months. No improvement had begun by the end of that time nor were there yet any signs of increased reflexes or tone at the knees. Dr. F. J. Davidson reported that after five months he was still paralysed but showed signs of increased tone in the lower limbs. This was the most severely affected patient of our series.

Case 5.—M. M., a young man of 24, was one of the milder cases. After preliminary cramps he found difficulty in walking because he could not lift up his feet. On admission on November 15, 1955, he had bilateral swelling of the parotids and complete foot drop. The muscles of the knees were also weak. There was a stocking anaesthesia below the knees, with loss of position sense and vibration sense and Rombergism. The toes were cold and moist. Position and vibration sense returned in a few days, but weakness of the hands began in the third week. At this stage, too, the knee jerks became markedly increased. Later, the biceps, triceps, supinator, and knee jerks were increased and the finger flexor test was positive on the right. Complete loss of power of the small muscles of the hands with marked wasting followed. No movements were yet possible at the ankles, although the quadriceps and hamstrings were recovering function. A slight hypoaesthesia of the soles and toes were the only remaining signs of sensory loss. Dr. Davidson reported that five months after admission M. M. showed signs of increased tone in the lower limbs.

Case 6.—D. M., a 7-year-old boy, was admitted on November 15, 1955. He had complained of cramps in the calves before admission. He was moderately affected, presenting with parotid swelling, a flaccid paralysis below the ankles, and slight sensory loss. Two weeks after admission he was found to have increased knee, triceps, biceps, and supinator reflexes. At three weeks his arms and hands became so weak that he had to be fed and the muscles of the hands and legs began to waste. He showed no improvement after six weeks in hospital except that the sensory loss had practically disappeared. The reflexes were still markedly exaggerated at the knee, triceps, biceps, and supinator tendons, and there was severe wasting of the anterior tibial muscles, the calf muscles and the peronei, also the intrinsic muscles of the hands. Five months after admission Dr. Davidson found the hyperreflexia and wasting to be still prominent.

Case 7.—E. M., the 11-year-old brother of D. M., was admitted on November 15, 1955, with symptoms and signs almost identical with those of D. M., including the parotid swelling. E. M. also developed hyperreflexia (save for the absent ankle jerks, as in his brother's case) after two weeks and marked weakness of the hands

after three weeks. Six weeks after admission he had lost all power in the intrinsic muscles of the hands, and wasting of these muscles and those of the lower limbs became apparent. Five months after admission Dr. Davidson found that there was still weakness of the affected muscles, hyperreflexia, and wasting.

Case 8.—El. M., the 9-year-old sister of D. M. and E. M., was affected in the same way as her brothers with parotid swelling and loss of power in the lower limbs on admission, on November 15, 1955, followed by hyperreflexia, again excluding the ankle jerk which was unobtainable in the third week. Loss of power and wasting in the intrinsic muscles of the hand was obvious by the fourth week. This little girl had an episode of vomiting and abdominal pain two weeks before admission, the only reported incident of the kind in this series and it may or may not have been related to ingestion of the poison.

Case 9.—S. H., aged 38 years, the mother of D. M., E. M., and El. M., and sister of R. H., gave a history of mild cramps in the calves preceding admission on November 16, 1955. She had had no fall, and there was no parotid enlargement. Her 1-month-old baby was breast-fed up to the time of admission. S. H. was, according to her relatives, a heavy drinker, and there were some signs of malnutrition. On admission she had extreme weakness at the knees and flaccid paralysis at the ankles. Hypoaesthesia was found below the ankles, most marked on the soles. After two weeks in hospital the upper limbs became affected, with loss of power in the hands. S. H. then refused further treatment and left hospital. We saw her at home six weeks after admission, when some improvement in power was noted, but the wasting and weakness of hands and legs was still marked.

Case 10.—A. N., a woman of 28 years, a heavy drinker and a constant visitor at the affected home, was admitted on November 16, 1955. She had bilateral swelling of the parotids, flaccid paralysis of the muscles at the ankle joints, and weakness of the muscles at the hip and knee. There was hypoaesthesia in a stocking distribution below the knees. Paralysis of the hands developed in the second week, at which point this patient also insisted on leaving hospital. When last seen in her home, six weeks after admission, the lower limbs had recovered some movement, the sensory loss had gone, and the parotid swelling was smaller. The knee reflexes and those of the biceps, triceps, and supinator tendons were exaggerated, and wasting of the hand and calf muscles was severe.

Case 11.—E. K., a man of 32, was first seen at his home on November 23, 1955, four months after he had become disabled by his disease. He refused admission to hospital on religious grounds. His illness had begun with calf pain and unsteadiness of the feet and soon after his hands began to feel weak. He had never noticed any parotid swelling. At the time of our first visit, he was found to have bilateral and complete foot drop and weakness of the hands. Plantar and ankle reflexes were absent, but there were increased jerks at the knee, the triceps, biceps, and supinator tendons. The only sensory disturbance was a slight hypoaesthesia of the soles. Palms and soles were cold and moist. Wasting of calf muscles and muscles of the hand was considerable. There was no parotid swelling.

When last seen, on December 19, 1955, five months after the onset, his condition had changed very little, there being still no movement at all at the ankles and little in the small muscles of the hands, but power at the knee had improved. Wasting and hyperreflexia had persisted. The finger flexor test was positive at this visit.

Special Investigations.—These were as follows:—

Cholinesterase.—Tests undertaken after six weeks of illness in five patients, and after five months in three patients, showed no significant changes in true cholinesterase levels. Pseudocholinesterase was not assessed. Local difficulties prevented further tests for cholinesterase from being undertaken.

Electromyography.—Electromyography showed partial and complete reactions of degeneration. The result was shown by plotting the voltage against the duration of the electrical muscle stimulus.

Cerebrospinal Fluid.—There was a rise of protein (50—80 mg.) in three of the 10 cases in hospital. No other changes were found.

Electrocardiography.—The electrocardiogram was normal in all but three of the 10 hospital patients. In two (G. N. and R. H.) the records taken four months after onset showed inverted T waves in leads V4, V5, and V6. (In lead V4 the pattern was still right ventricular.) In the case of R. H. after five months of illness, there was a normal T wave in V6 and the inversion in leads V4 and V5 was less marked. The records of the third patient (M. M.) taken two weeks and six weeks after the onset of paralysis showed elevated ST segments with left ventricular pattern in leads V3, V4, V5, and V6. All three patients were comparatively well nourished. Blood pressures were respectively 180/100, 160/100, and 130/80 mm. Hg. There was no evidence of heart failure and the chest radiographs were normal. No evidence is adduced connecting the electro-cardiographic changes with T.O.C.P. poisoning.

Urine.—In no case did the urine contain oxalate crystals, as had been reported in the 1937-38 outbreak. Routine tests for sugar and albumin were negative in all cases.

Other Special Investigations.—The present series of patients had negative serological reactions for syphilis in the blood and the cerebrospinal fluid. Blood smears and urine analyses helped to exclude mercury, arsenic, and lead poisoning. Serological tests for viruses, including mumps, were negative. Blood counts, tests for porphyrins, and a battery of liver function tests were all within the usual limits for the local African population.

Clinical Features

The syndrome of T.O.C.P. poisoning is distinctive and in a typical case the diagnosis should be made on the clinical picture alone.

FIG. 1.—Parotid swelling two weeks after onset in A. D.

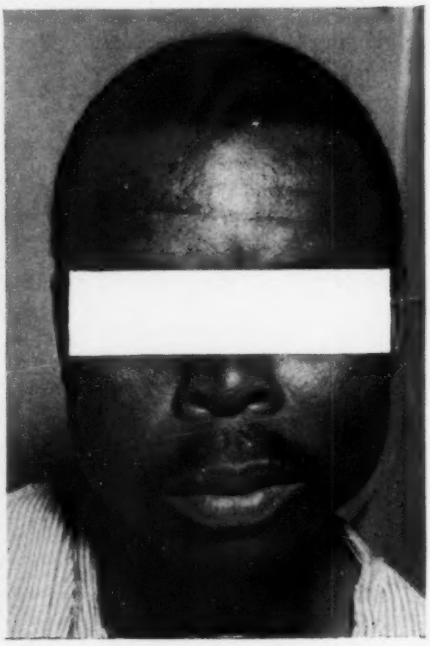

FIG. 2.—Residual parotid swelling four months after onset in R. H.

Prodromal Symptoms.—Shortly after ingestion of the poison there may be a gastro-intestinal disturbance with nausea, vomiting, and diarrhoea. This is usually transient, lasting from a few hours to a few days. The disturbance is by no means invariable; it occurred in only one case of the present series, and in three of the 16 cases of the 1937-38 Durban outbreak. It was common in some groups of the American outbreak and not in others. There, in all cases, the poison tended to be taken in large doses over a short period so that dosage is probably not related to the appearance of gastro-intestinal symptoms.

Symptoms of Onset.—There follows a latent period of from three to 28 days, the duration of which is probably dependent on the size of the dose and the period of time over which it was ingested. The symptoms that follow herald the paralysis. Nearly all patients complain of sharp, cramp-like pain in the calves, and some of numbness and tingling in the feet and sometimes the hands. Within a few hours or a day or two at most these pains are followed by increasing weakness of the lower limbs and soon the patient becomes unsteady and then unable to keep his balance; if he walks it is with the stamping gait of bilateral foot drop. The cramp-like pains may cease with the onset of weakness or persist for some days; in a few cases they persist for months or even years, while in others they are replaced by a dull, aching pain. In some patients, an abrupt fall to the ground, described as fainting or dizziness and probably due to weakness of the lower limbs, is the first symptom after the latent period. Cramps may or may not follow this dramatic onset. It is at this stage that the average case of moderate severity reports to the physician.

Constitutional Signs.—In Durban in 1937-38 Drummond noted a euphoria. Our patients showed perhaps unusual equability of temper in the face of severe disability. They were apyrexial and there were no other general signs, but without exception the hands and feet were cold and sweating profusely, a sign that may persist for months. Aring (1942) noted that his patients invariably had cold and cyanotic hands and feet; in our African patients the cyanosis could not be confirmed. In two patients who suffered from malnutrition and parotid swellings, the soles and palms desquamated after some weeks.

Parotid Swelling.—Of the 10 patients seen in hospital, seven had a definite diffuse, more or less symmetrical enlargement of the parotid glands

(Fig. 1). This swelling was not tender, it was of recent origin, and gradually diminished over several weeks (Fig. 2). On palpation the swelling was firmer than that associated with malnutrition but less firm than that of mumps. Parotid enlargement is not a feature that has been observed in other outbreaks.

Motor Changes.—Usually, when first seen, the patient is considered to have symmetrical polyneuritis. He has bilateral foot drop with complete loss of power from the ankle down. Depending on the severity of the affection, he may have weakness at the knees, less at the hips, and, only in the most severe cases, weakness of the trunk. Symmetry is very close but not absolute.

The ankle jerks are absent. Knee reflexes may be normal or occasionally depressed. Sometimes, even at this early stage, they may be exaggerated, presaging the development of increased tone. Plantar reflexes are unobtainable, probably on account of the complete loss of power. They have on occasion been described as present or normal (Zeligs, 1938; Hunter *et al.*, 1944). This is unusual and may reflect mild involvement without complete loss of power.

Sensory Loss.—Several authors state emphatically that sensory changes do not occur. Aring (1942) considers that in most cases of which he had knowledge a report of loss of sensation was a reflection of an inadequate examination. Sampson (1942) reported sensory changes although these were admittedly unobtrusive in contrast with the motor phenomena, and Burley (1932) noted especially loss of vibration sense. Reports of muscle tenderness and nerve tenderness are fairly frequent. In the present series all the patients showed sensory loss. The degree conformed roughly but not exactly to the degree of motor loss and varied in extent from merely the soles of the feet to the whole of the limbs and even the trunk. There was a similar range in the upper limbs but, as with the motor manifestations, changes tended to appear a few days later than the lower limb affection. Usually there was anaesthesia or hypoaesthesia with loss of pin-prick and temperature sense; vibration sense was sometimes affected distally. In two of the milder cases there was for the first few days, loss of position sense and Rombergism. Muscle tenderness to pressure was found in a few of our patients. However, in comparison with the motor dysfunction, the sensory changes were not prominent.

The Upper Limbs.—One or two weeks after the onset of paralysis in the lower limbs and while this paralysis may still be progressing, weakness invades the hands. Some patients show complete wrist drop and total loss of power in the hands, with weakness up to the elbows. Neither weakness above this level nor cranial nerve palsies are described except in one fatal case where the dose of T.O.C.P. was enormous. Sensory changes, usually milder than in the lower limbs, are now found in the hands.

FIG. 3.—Wasting of the small muscles of the hand four months after onset, with wrist drop, in R. H.

Wasting.—About three weeks after the first paresis a most striking and rapid wasting may be observed. While the small muscles of the feet, the calves, the anterior tibials, and the thighs do not escape, in so far as they are involved in the disease, the change is most obvious in the small muscles of the hands (Fig. 3). These are symmetrically and uniformly involved as though there were a complete lesion of the ulnar and median nerves. Muscle fibrillation has been reported (Hunter *et al.*, 1944) but was not observed in the present series.

Upper Motor Neurone Involvement.—At about this time, another diagnostic feature becomes obvious. Earlier signs may have suggested the involvement of the pyramidal tracts but this only develops definitely by about the third week or later. The knee jerks now become exaggerated and so also may the biceps, triceps, and supinator jerks. A finger flexor reflex may appear for the first time or increase. In severe cases, the signs of upper motor neurone affection are delayed, probably masked by the gross weakness. The mildest cases may not show upper motor neurone involvement at all. After six weeks these signs were not obvious in three severe cases and one mild case of the present

series but they were evident in the other seven. As the pyramidal tract lesion develops, involuntary flexor withdrawal of the whole limb follows gentle plantar stimulation. Babinski responses are seen much later.

Earlier descriptions of T.O.C.P. poisoning have not emphasized the appearance of pyramidal tract signs within the first month. These signs are of diagnostic importance.

Regression.—The muscular weakness progresses over several weeks, sometimes even months, before it becomes stationary. Sensory changes often begin to regress in the early weeks and then power returns gradually in patients who are only mildly affected. The milder the case, the sooner sensory changes regress. Improvement begins with sensation, then power in the hands, then power in the lower limbs. Flesh slowly returns to the muscles. Improvement continues gradually over the next year or more. One of our patients who was affected in 1938 felt that he had continued to improve for about four years. In the present series, sensation had begun to improve in all cases from one week to three months after onset. Power began to return in from one to four months.

Prognosis.—Many authors state that most cases recover completely. While it is true that many are rehabilitated a large number of patients do not regain normal function of the central nervous system. Zeligs (1938), writing eight years after the United States outbreak, surveyed the records of 316 patients. He was able to follow up 60 patients, all of whom were disabled and still in institutions. Aring (1942) examined more than 100 patients in the 10 years after the same outbreak and these appear to have been still affected. Of the 80 patients in the Swiss incident, 14 were quite well after five years, 15 were totally incapacitated, and 38 showed " muscular pseudospasticity " (Walthard, 1946). Our four patients, after 18 years, all show some signs of disease. The mildest case has slight weakness at the ankles, while the most severely affected has bilateral positive Babinski reflexes with involuntary flexor withdrawal, increased tone and ankle clonus, spastic gait, foot drop, wasting, and persistent cramps. The residual signs and symptoms were entirely confined to the lower limbs, and this has also been the experience of other observers. All four patients are rehabilitated socially and economically and the two seriously disabled members of the family make light of their disabilities as they did at the onset. They are in touch with another victim of the Durban 1937-38 outbreak and report that he still has bilateral foot drop.

The patients involved in the present outbreak who were seen up to five months after onset were all still affected. There was weakness and wasting of varying degrees in the feet and the small muscles of the hands, and seven showed upper motor neurone signs.

Special Investigations.—From experimental evidence a depression of the pseudo-cholinesterase level would be expected, with a normal or moderately depressed true cholinesterase. Pseudo-cholinesterase was not measured in our series and no significant changes were found in the few assays of true cholinesterase that we were able to make.

Electromyography has shown partial and complete reactions of degeneration in all cases so far reported. It is unlikely, in view of the normal true cholinesterase levels and the clinical picture, that there is any neuro-muscular block.

Cerebrospinal fluid changes have usually been confined to a rise of protein in a few cases with occasionally a small increase in lymphocytes. Zeligs (1938) stated that only two of his 120 cases showed a rise in protein while an increase in cells was more common.

Diagnosis

The characteristic features of the illness are found, as in many other nervous diseases, in the sequence of developing lesions and in their unusual combination. The patient presents with a predominantly motor polyneuritis causing bilateral foot drop and a history of cramps in the calves for the preceding few days. The extremities are cold and sweating. Soon the lesion invades the hands; rapid and symmetrical wasting of the calf muscles and the small muscles of the hand is seen next and shortly afterwards exaggerated jerks appear at the knee and perhaps also in the upper extremities.

A diagnosis of polyneuritis may be made, especially where the protein level in the cerebrospinal fluid is raised, until the upper motor neurone lesion develops. Motor neurone disease produces the same combination of lesions (even sensory changes have been described) but the sequence of events, the rate of development of the lesion, and the progress of the wasting and its limited distribution, as well as the usual absence of muscle fibrillation, should readily exclude this disease.

Tri-ortho-cresyl phosphate is an irreversible cholinesterase inhibitor. The only other anticholinesterases known to produce a delayed paralysis are the organic phosphorus insecticides " mipafox " and, experimentally, di-isopropyl-fluorophosphonate (D.F.P.). In Germany a similar paralysis following " parathion " poisoning has been described; parathion is an organic phosphorus insecticide but

experimentally it has failed to cause delayed paralysis. In the case of the organic phosphorus insecticides, a history of exposure generally suggests the nature of the disorder. There is in these cases also a typical history of acute cholinergic symptoms at the time of exposure, with flaccid paralysis and vomiting and diarrhoea which may be violent and sustained. While mild gastro-intestinal symptoms may occur with the ingestion of T.O.C.P. these are inconstant and not immediate. Certainly, the delayed paralysis of " mipafox " mimics that of T.O.C.P. Bidstrup, Bonnell, and Beckett (1953) show a photograph of a wasted hand with a lesion precisely similar to those found in our patients.

The effect of T.O.C.P. on pseudo-cholinesterase is marked and prolonged but true cholinesterase is not inhibited to any major degree (Earl and Thompson, 1952; Aldridge, 1954). On the other hand, " mipafox " inhibits true cholinesterase as well as pseudo-cholinesterase; reduced levels of both are found in patients with " mipafox " poisoning.

Pathology and Toxicology

The essential lesion in patients who die of T.O.C.P. poisoning in either acute or chronic phases and in animals is myelin degeneration of the peripheral nerves, the anterior nerve roots, the columns of Goll, and the lower pyramidal tracts. In animals, the spino-cerebellar tracts and the long association fibres of the anterior columns also suffer demyelination. In the acute phase there is chromatolysis of the cells of the anterior horns of the spinal cord, while in the chronic phase these cells are reduced in number (Smith *et al.*, 1932; Aring, 1942; Goodale and Humphreys, 1931; Earl and Thompson, 1952; Aldridge, 1954).

The probable pathogenesis of the lesions is as follows:—(1) The differing immediate cholinergic effects of " mipafox ", D.F.P., and " parathion " on the one hand and T.O.C.P. on the other, are due to their variable action on true cholinesterase. The former group depress cholinesterase levels and produce severe effects; T.O.C.P. does not depress the level, and symptoms are absent. (2) The paralysis which follows T.O.C.P. poisoning and may follow " mipafox " and " parathion " poisoning and can probably follow D.F.P. poisoning (as it does in hens) is directly related to demyelination. (3) The demyelination may be the result of a similar action by these poisons against an enzyme, possibly pseudo-cholinesterase or one related to it, which is concerned in the nutrition of myelin.

Aetiology of the Parotid Enlargement

The parotid swelling is a feature that has not been noted in previous outbreaks. Parotid swelling in South Africa is commonly seen in malnourished African subjects. In such cases the development is imperceptible, the swelling is soft and it does not subside rapidly. Signs of malnutrition can be found in the great majority of urban African location dwellers. In this group of seven patients with the parotid swelling of T.O.C.P. poisoning, five showed mild, *i.e.*, average, malnutrition, one was distinctly malnourished (and alcoholic), and one was clinically well nourished (and an abstainer.) The three children were all mildly malnourished and all affected. The recent origin and steady subsidence of the parotid swellings in our cases of T.O.C.P. poisoning excluded malnutrition as a prime cause. Both clinically and serologically mumps was excluded as a cause. Arsenic trioxide, botulism, iodides, lead, and sulphuric acid (Von Oettingen, 1952) were unlikely to be the cause.

A possible relationship with the parotid swelling found in malnutrition is suggested by the fact that pseudo-cholinesterase levels are depressed in human malnutrition as well as in T.O.C.P. poisoning (Hutchinson, McCance, and Widdowson, 1951). Another possibly related finding was that the essential histological changes in rats following chronic " parathion " poisoning included changes in the salivary glands. Perhaps T.O.C.P. has an effect on the salivary glands which only becomes manifest in a gland already suffering from nutritional deficiency. The absence of such swellings in other outbreaks is difficult to explain, as is also the limited distribution of parotid swellings in malnutrition.

Treatment

No known treatment has any specific effect and measures are limited to the necessary physical and moral support. Bidstrup, *et al.* (1953) found that early activity in delayed " mipafox " paralysis, while cholinesterase was still depressed, caused spasms and twitching. No such effect was observed in the present series in spite of early activity. Only one patient complained of ready fatiguability. The impression in previous outbreaks was that those who tried hardest and were most active did best, but the most severely affected may have been too grossly impeded to try. The present series has not been long enough under observation to discuss this further. The family poisoned in Durban in 1937-38 all believe that the severe effects persisting in the father and daughter were due to their uncurbed activity in the early stages, while the mother and son, who have escaped very lightly, carefully obeyed medical injunctions to remain at rest.

Summary

An outbreak of T.O.C.P. poisoning in 11 African patients in Durban, South Africa, in 1955, is described.

The mode of poisoning is discussed and from the epidemiology of this outbreak it is suggested that water, as well as the previously reported solvents such as lipids and alcohol, may be a vehicle for the poison, either in solution or suspension or both.

This is the first outbreak to be reported in relation to the industrial use of T.O.C.P. as a plasticizer; the necessity for precautions in industry is stressed.

Family and social and occupational factors are shown to be important in diagnosis.

The clinical picture, which includes a delayed flaccid paralysis with subsequent upper motor neurone signs, is emphasized as an important and reliable guide to diagnosis. The pathology and aetiology of the nervous lesions are discussed.

Swelling of the parotid glands is reported in this outbreak for the first time.

A follow-up after 18 years on four patients poisoned in 1937-38 shows that disability may be profound and permanent.

Our thanks are due to Dr. J. Drummond for his help and for his data from the previous Durban epidemic; to Dr. Donald Hunter for his advice on the manuscript; to Dr. S. Disler, Medical Superintendent of the King Edward VIII Hospital, for permission to publish, and to Dr. D. Pooler, Dr. F. Davidson, Dr. K. Drummond, and Professor B. Adams for giving us access to their patients. We are grateful to the staff of the Durban City Health Department for their assistance in following the investigation to the homes of the patients and to the factory. We are indebted to Dr. M. K. S. Hathorn for the photographs.

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INTERNAL DERANGEMENT OF THE KNEE JOINT IN MINERS

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(RECEIVED FOR PUBLICATION JANUARY 28, 1957)

Internal derangements of the knee joint appear to be prevalent among British coal-miners. In recent years such injuries have accounted for between 15 and 30% of all cases admitted to the rehabilitation units provided in each coal-field, and at which a large proportion of miners suffering from acute orthopaedic disabilities are treated, as well as some of those suffering from the more chronic orthopaedic conditions. Occupational and non-occupational conditions are treated alike at these centres.

Precise figures are not available for the incidence of these internal derangements among miners, for notification of them is not made to the Inspectorate of Mines, nor is it likely that all are reported at collieries. An indication of their frequency is given by the fact that about 150 such cases (including cases of injury to a collateral ligament, but not of bursitis) are treated annually at the residential rehabilitation unit which serves the South Wales coal-field. If to these is added the number of cases treated solely at hospitals and at the small rehabilitation units attached to some of their orthopaedic departments, we may assume that certainly not less than 200 fresh cases occur annually in a working population of under 110,000 men. Figures of a similar order are obtained from the English and Scottish coal-fields. Such an incidence is probably higher than that in heavy industry outside the mines in Britain. Figures for a South Wales steelworks employing over 8,000 men (Jones, J. G., 1956, personal communication) suggest that steelworkers suffer an annual incidence of comparable knee-joint injuries which is little more than half that experienced by miners.

It is known that in other countries also this problem is a large one. In Germany, about 600 fresh cases of meniscus lesions are said to occur annually in the Ruhr coal-field, where damage to a meniscus in mineworkers is accepted for compensation; it is suggested that the nature of their work, often performed in a crouching posture, results in degeneration of the meniscus (Husten, 1953).

In studies undertaken among miners in Lancashire, Kellgren and Lawrence (1952) and Lawrence (1955) demonstrated a high prevalence of symptoms referable to the knee joint. These workers seem not to have investigated the connexion between various types of injury to the joint and the osteo-arthritis in which they were mainly interested. But they demonstrated osteo-arthritic changes radiologically in the knee joints of 17 to 35% of sample populations of underground workers aged 40-50 years, and after investigation of various possible aetiological factors stated that " apart from injury to the knee we have found no factor in mining which appears causally related to osteo-arthritis." Bonar (1950), analysing 200 cases of meniscectomy among Scottish miners, noted that injury to the menisci was commonest among coal-face workers, and from his figures it appears that they suffered an incidence 72% above that for miners as a whole. Smillie (1951), whose profound studies of injuries of the knee joint are largely based on his experience among Scottish miners, stresses the aetiological importance of work in narrow seams.

It seemed worthwhile to undertake some further examination of the extent of this problem, and particularly to investigate the nature of the accidents and other types of trauma which may be responsible for these injuries.

The material for study consisted of patients undergoing rehabilitation at a residential unit in South Wales during 1953. One hundred consecutive cases of presumed damage to a knee cartilage were studied, including 22 cases where a final decision to perform meniscectomy had not been reached, but in which there seemed a likelihood that a meniscus lesion would ultimately declare itself. In 78 cases meniscectomy had been performed, and lesions of a cartilage sufficient to account for

symptoms had been found in all but one of these. This series was not fully representative of cases admitted to this rehabilitation centre, for of the cases of soft-tissue knee-joint injuries rehabilitated there, only about half are cases recovering from meniscectomy.

Meniscus Injuries as a Cause of Disability

As is well known, damage to the meniscus is commonly recurrent and causes recurrent symptoms. Thus in a series of 186 meniscectomy cases Duthie and Macleod (1943) found that half the subjects had previously been in hospital with symptoms before admission for operation. Care was therefore taken in this enquiry to elicit a complete history relative to the affected knee and not simply one concerning the latest incident leading to operation or rehabilitation at the unit. It was explained to the men concerned that all information to be volunteered would be treated in the strictest confidence, and could thus not prejudice any claim for injury benefit or compensation; it can therefore be claimed that, within the limits of the patients' memories, the histories obtained were reasonably accurate.

However, detailed memory for events which sometimes covered many years must inevitably afford only an approximate answer to the question of what is the average loss of working time before hospital treatment begins. The period from onset of symptoms until return to work after rehabilitation averaged 21 weeks in this series. It is likely that this is an underestimate of the true average period of disability, for some at least of the 22 patients not operated upon are likely to have further symptoms, probably more troublesome than those who have had meniscectomy performed. Bonar (1950) recorded an average total disability in his series of about seven weeks, the period tending to be longer with increasing age. It is not clear, however, that his calculations took account of disability arising from earlier symptoms before the final breakdown. Smillie (1951) quotes series of 16 and 25 weeks' average total disability, also among Scottish miners.

It is thus evident that these injuries represent a serious problem in terms of economic loss both to the miner and the nation. For comparison, 50 consecutive cases of fracture of the tibia and fibula, a severe injury not uncommon in miners, who were treated at the South Wales Rehabilitation Unit in 1953, lost an average of 36 weeks' work. Figures from this Unit and from notifications made to the Mines Inspectorate indicate that about 65 cases of this injury occur annually in South Wales mines compared with some 200 cartilage injuries. In aggregate, therefore, soft-tissue injuries of the knee joint represent a much greater drain on manpower than do these more spectacular fractures.

Much of this disability time is caused by delay in obtaining specialist advice. Thus in this series of 100 men there were 140 well defined and separate periods of disablement, each of three or more days' duration, arising from definite traumatic incidents. These men suffered in addition numerous lesser episodes provoking symptoms, severe enough in some cases to cause loss of work for a day or two; many suffered prolonged periods of impaired efficiency. In this series, no less than 10 weeks of the total 21 weeks' disability, on average, had occurred before specialist advice had been secured for symptoms which, in the majority of cases, must inevitably have suggested injury to a cartilage. Duthie and Macleod (1943), noting an average duration of symptoms before operation of two years nine months in their series, entered an eloquent plea for earlier recognition of these injuries. It seems possible that the degenerative lesions described by Husten may, in some cases at least, have been due to such recurrent injuries.

Some of the possible explanations for these delays are examined by Smillie, who points to the key position occupied by the general practitioner in these cases. The industrial medical officer is also often in a position to influence these delays.

Finally, there is the difficult question of long-term disability. Whatever may be the truth about the development of osteo-arthritis following meniscectomy, there appears to be no dispute that neglect of a torn meniscus speeds this untoward development (Smillie, 1951). The following case seems to illustrate this point, and also Smillie's teaching on the traumatic origin of cysts of the meniscus.

A 31-year-old collier was struggling to right an overturned tram of coal while in a squatting position, when he slipped. Twisting a knee, which became locked, he lost some four months' work. Symptoms recurred on his return to work, and a lump appeared on the outer side of the joint-line. This (undoubtedly a cyst of a damaged lateral meniscus) was removed without exploration of the joint. Eleven years later, as the knee was unstable and had caused periodic absences from work, the joint was explored and the remnants of this meniscus removed. Despite full rehabilitation, the joint continued to give trouble and acute symptoms followed a slight stumble at work. Further exploration of the joint revealed advanced osteo-arthritis at the age of 44 (not present in the other knee), for which removal of the patella and anterior arthroplasty was performed.

That meniscus lesions are frequently accompanied by osteo-arthritic changes was noted by Adamson (1946), while in Bonar's series osteo-arthritis was demonstrated radiologically in "fully 50%" of knees operated upon. Unfortunately the incidence

of osteo-arthritic changes in the sound knees of these cases was not recorded. Such a study would have afforded valuable evidence on the inter-relationship of these conditions.

There have been few attempts to follow cases of meniscus lesions beyond the first months after meniscectomy. Fairbank (1948) examined radiologically a series of cases at varying intervals up to 14 years after meniscectomy; he found narrowing of the joint space in 32% of knees which had been submitted to medial meniscectomy and in 40% of those from which a lateral meniscus had been removed. He suggested that this narrowing would predispose to degenerative changes, but was unable to decide whether there was a connexion between the various radiological changes he observed and the later appearance of osteo-arthritis.

Factors in the Causation of Meniscus Lesions

Age.—Table 1 shows the ages at which the first definite symptoms of meniscus damage (accompanied by incapacity of three or more days' duration) occurred. This age distribution accords with those in other published series (Bonar, 1950; Adamson, 1946) in showing a maximal incidence of first symptoms between the ages of 20 and 40.

TABLE 1

AGE AT FIRST ONSET OF SYMPTOMS IN 100 CONSECUTIVE CASES OF MENISCUS INJURY CAUSING THREE OR MORE DAYS' INCAPACITY, AND RATE PER 1,000 EMPLOYED BY AGE GROUPS

Age in Years	No. of Cases	No. on Colliery Books	Rate per 1,000 Employed
16–20	9	9,624	0·94
21–30	27	18,861	1·43
31–40	32	24,053	1·33
41–50	25	24,361	1·03
51+	7	27,147	0·26

Sport.—Cartilage lesions are notoriously common among athletes, particularly footballers. The onset of symptoms in middle age may be held, therefore, to be presumptive evidence against sport being a major factor in the production of these injuries among miners; it is rare, in my experience, to find miners taking part in any sport after the age of 25, and few indulge in strenuous sport other than football.

Table 2 shows that symptoms originated during some sporting activity in 13% of cases. As a rough check on the accuracy of the histories given regarding the circumstances of the injuries in this series, the dates were noted when symptoms occurred, wherever this could be recalled with any certainty. The distribution of these episodes was: March 1-August 31, 50 incidents, September 1-February 28, 67 incidents. Such seasonal variation could well be explained by a combination of football injuries and extra liability in winter to slipping accidents above ground. It seems likely, therefore, that sport does not account directly for more than about 15% of meniscus injuries in miners, though what its influence may be on the occurrence of symptoms in later years remains undetermined.

TABLE 2

NATURE OF ACTIVITY RESPONSIBLE FOR INITIAL AND SUBSEQUENT INJURIES CAUSING THREE OR MORE DAYS' INCAPACITY IN 100 CONSECUTIVE CASES

Nature of Activity	(i) No. of Initial Injuries			(ii) No. of Subsequent Injuries			(iii) Total Injuries Caused			(iv) Percentage of Total Injuries
Non-mining			16			7			23	
Sport		13			5			18		12·9
Football	11			5			16			
Other	2			0			2			
Other non-mining		3			2			5		3·6
Mining			82			33			115	
Surface		8			7			15		10·7
Underground		74			26			100		
On roads	29			16			45*			32·1
At coal-face	45			10			55			39·3
Undefined			2			—			2	1·4
			100			40			140	100

* One of these injuries occurred in the pit-shaft.

Mining Occupation.—In this series 54% of cases studied were face-workers, 35% were employed elsewhere underground, and 11% were surface workers. The actual distribution of man-power in South Wales mines was: Face-workers 46%, others underground 35%, surface workers 19%. It did not appear, therefore, that precise occupation within the industry was a major factor in the production of these injuries.

Table 2 shows that of the 140 major incidents (those causing three or more days' incapacity) suffered by the men in this series, 100 occurred below ground. Of these latter, 55 occurred at the coal-face, 44 on roadways, and one in the pit-shaft. Here again, there is fairly close correlation with the distribution of mining populations at risk, though there is some support for the view that coal-face work is attended by greater risk of meniscus damage than is other mining work. These figures, however, certainly do not suggest that work at the coal-face, at least in South Wales, is the main cause of the high incidence of these injuries among miners, as Smillie appears to suggest is the case in Scotland (Smillie, 1951). Smillie there draws attention to the type of case in which a coal-face worker tears a mensicus in getting up from a crouched position within a confined space, pointing out that the strain of such a working position gradually stretches the posterior peripheral attachment of the meniscus, allowing it to become caught between the condyles

on some occasion when the joint is extended from the flexed position.

Of the 55 coal-face incidents in this series, nine occurred to men while crawling, kneeling, or squatting in a thin seam, the direct cause, however, being a blow from falling coal, roof, or support, or violent evasive action to avoid such a blow. In a further 10 incidents there was no such external factor, the injury occurring either while the body pivoted upon the knees, as in throwing or shovelling on to a conveyor (three incidents), or slipping while kneeling on an uneven surface (two incidents); in only five incidents did the injury occur on rising from the crouched or kneeling position, the mechanism described by Smillie. It is noteworthy, however, that in two of the latter incidents the patients were unaccustomed to work on their knees and had done so only for a few hours; the same was true of the two similar incidents which occurred in men working on the surface. Thus it would appear that, at least in South Wales, the mechanism described by Smillie is something of a rarity, and other factors must account for the majority of the cases there.

As will be seen from Table 3, the largest number of coal-face incidents was due to falls of roof or coal which directly caused 20 incidents and indirectly, by inducing violent evasive action, a further two. Next in importance, and ranking nearly equal with the combined direct and indirect consequences of kneeling, were slipping and tripping incidents at the coal-face (15 incidents), which do not include slipping accidents while crawling. Crawling or kneeling was the main factor in the injury in 10 out of 55 coal-face incidents.

TABLE 3

PRINCIPAL MINING FACTORS RESPONSIBLE FOR INITIAL AND SUBSEQUENT INJURIES TO MENISCI

	No. of Injuries Caused by Given Factor Underground			
	Surface	Roadways	Coal-face	Totals
Kneeling and crawling	2	—	10 (9)	12 (9)
Fall of stone or coal	—	3	20 (2)	23 (2)
Haulage accident	—	9 (2)**	—	9 (2)
Tripping or slipping	7	30	15	52
Miscellaneous	6	3*	10	19
	15	45 (2)	55 (11)	115

* Includes one incident occurring in pit-shaft.
** The number of occasions on which a given factor was partially responsible for injury is shown in brackets.

It might have been expected, had kneeling at work been the major factor in these injuries, that lesions of the right knee would be more frequent than those of the left, for weight is probably thrown more on the right knee in the right-handed majority when work is performed in a low place. Of the 45 men in the South Wales series whose first symptoms arose at the coal-face, 22 had suffered injury of a meniscus of the left knee and 23 of the right knee. As might have been expected, however, the left knee was the site of injury in the three cases where symptoms originated in the act of shovelling or throwing on to the conveyor from the kneeling position.

Slipping and Tripping Accidents.—Table 3 shows the important role of tripping and slipping accidents in the production of meniscus lesions in miners. Fifteen such incidents occurred at the coal-face, amounting to one-third of the coal-face incidents. The majority (30 out of 44) of the roadway incidents were caused by slipping or tripping, and this figure would be increased if some of the haulage incidents were included under this head, where men slipped in handling trams of coal and the like. Of the 15 incidents occurring on the surface of the mine, seven were due to slipping or tripping.

Analysis of the coal-face incidents showed that the difficulties of negotiating a conveyor caused most of these slipping and tripping accidents (10 out of 15 incidents). It is possible that in some of these cases the conveyor was in motion at the time (the point was not investigated) but even when stationary a conveyor represents a considerable obstacle, especially in a confined space, while the risk of slipping is great when traversing a conveyor on an inclined coal-face. It is probably significant that no case occurred in this series of slipping or tripping while negotiating a conveyor in the less confined conditions of a roadway.

The majority of the 30 slipping and tripping incidents which occurred on underground roadways were due to slipping on steel rails or the sleepers of the haulage track (18 incidents). Others were falls on a " greasy " patch of roadway (three incidents), tripping on uneven ground (five incidents) or over some obstruction (three incidents), and slipping on a smooth steel cover plate on the roadway in one case. It was a feature of many of these incidents that the mishap occurred while the miner was burdened with some heavy object or was struggling to manoeuvre coal trams.

Slipping on smooth steel plates was also the cause of two meniscus lesions in surface workers. The danger of these surfaces, especially to men wearing hob-nailed boots, was illustrated recently when a miner controlling trams at a surface tippler slipped in his nail-studded boots on the smooth sheet surround and fell into the tippler, where he received immediately fatal injuries.

In connexion with these roadway incidents it is of interest that Lawrence (1955) found a greater prevalence of osteo-arthritis, as judged both by

symptoms and radiographs, in the knees of roadway workers than in the knees of other mining groups he studied. Such findings and those presented here relating to non-faceworkers need to be qualified by his warning that faceworkers with injured knees may tend to leave the coal-face for work outbye.

Other Derangements of the Knee Joint.—As mentioned above, meniscus injuries which are sufficiently definite to warrant meniscectomy make up about half the cases of internal derangement of the knee joint treated at the miners' rehabilitation unit where cases have been studied. The other half consists of cases of traumatic effusion (sometimes of uncertain origin), osteo-arthritis, and injuries to the collateral ligaments. Of these latter, the medial ligament is much the more commonly affected, and the mechanism of its injury is similar to that of meniscus lesions (Smillie, 1951). Injuries of the medial ligament make up a not insignificant group among the knee-joint injuries seen in miners, as might be expected in an occupation where work with the knees semi-flexed is not uncommon (Wilson, M., 1954, personal communication). They frequently occur in conjunction with meniscus injuries, as noted by Smillie.

An interesting case of chronic strain of the medial ligaments was seen at a colliery recently. A conveyor shifter nearly 6 ft. in height had worked in a seam averaging 3 ft. 6 in. in thickness for about two years when he began to experience aching pain in the knees. When seen, he had been compelled to take several periods of absence from work, and exhibited unmistakable signs of injury to both medial ligaments. These injuries were clearly due to his task of straddling the conveyor while pans were being detached or assembled in the new position; because of his height in this narrow seam, this had to be done with his knees semi-flexed and abducted. It proved necessary for this man to find other employment.

Conclusions

In view of the recent interest in miners' osteo-arthritis which has been stimulated by the studies of Kellgren and Lawrence, it is desirable that attempts should be made to elucidate further the relationship between the osteo-arthritis of the knees which they have shown to be so prevalent and meniscus injuries also prevalent in miners. One method of studying this relationship, which should not present great difficulties, would be to radiograph both knees of a series of cases being submitted to meniscectomy, and such a study is now contemplated.

The challenge presented by these injuries is considerable. If any features of the mining environment are found to contribute materially to this loss, it would obviously be desirable to attempt their elimination. The present study indicates that such factors include work in confined places, injury by falling roof, coal, or supports, and haulage accidents.

In so far as work in low seams is a factor in the production of these injuries, reduction in the number of cases can probably only be brought about by mechanization, which will reduce the number of men at risk. This process is taking place fairly rapidly. The present study has not confirmed the theories that the postures adopted for work in narrow seams lead to degenerative changes in the menisci (Hunsten, 1953) or to increasing mobility of the menisci, leading to their injury in normal joint movement (Smillie, 1951). On the contrary, although coal-face workers in South Wales appear to suffer a somewhat increased risk of meniscus injury compared with other groups of mineworkers, the affected face-workers had almost invariably experienced specific trauma of a type and severity which might have been expected to produce injury to a normal meniscus. Again, the fact that the incidence of these injuries does not appear to rise in successive age groups, but is greatest in the decade 21-30, does not suggest a degenerative process of any slowly developing type. It seems rather that repeated specific trauma, together with personal variations in susceptibility to this, account best for the incidence observed in these mineworkers.

Falls of ground and haulage accidents have for long received attention from those concerned with mine safety and their efforts have had considerable success. Only recently, however, has much attention begun to be paid to slipping and tripping accidents, which are so frequent a cause of knee-joint injuries in the mines. It is probable that slipping and tripping, besides directly causing these and other injuries, are also not inconsiderable factors in many of the more serious haulage accidents. A determined attack upon this problem should prove rewarding.

It is possible that the present types of miner's boot could be improved by the use of soles less liable to slip than the present rubber or steel-studded leather soles, and the " commando " type of boot now available has some advantages. The improvement in mine roadways which has been a feature of the National Coal Board's development programme may be expected to reduce the number of slipping and tripping accidents, as also may the general improvement in " housekeeping " both below and above ground at coal-mines. There is clearly need for managements to have always in mind the provision and maintenance, wherever men have to travel on foot, of walkways in good repair

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unencumbered by obstacles or haulage tracks. Avoidance of smooth steel surfaces on footplates, manholes, steps, or machinery housings upon which men may tread is another obvious need.

Further improvement of general lighting may also be expected to reduce these accidents. Light from a cap-lamp fixed to the helmet affords no protection from tripping or slipping upon objects or surfaces underfoot unless the gaze is directed sharply downward; the result of this movement may easily be failure to see an obstruction at head height.

The grosser dangers associated with conveyors are well known. What is not generally realized is the danger of knee-joint injury inherent in traversing them, especially in confined places, even when they are stationary.

Another matter upon which the miner might with advantage be better informed, and which the doctors who see his injuries in their earliest stages might profitably bear in mind, is the importance of ensuring that these injuries receive without delay the benefit of the specialist attention and excellent rehabilitation facilities which are available. There are good grounds for assuming that such treatment is beneficial both on a short- and long-term view, even though fully satisfactory proof of this may at present be lacking and indeed may never be possible.

Summary

The problem of damage to the menisci of miners has been studied in a series of 100 men, drawn without selection from those undergoing treatment at a rehabilitation unit in South Wales in 1953.

It is shown that these injuries are common and of considerable importance in the mining industry. They are predominantly of occupational origin.

The consequences of injury to menisci in terms of disability are described and their possible relationship with osteo-arthritis is discussed. The factors in mining which appear to contribute to the occurrence of these lesions have been studied. Kneeling in narrow seams is of itself by no means the only, or even the main, cause of them. Attention is drawn to the importance, as causal factors, of slipping and tripping both at the coal-face, on underground roadways and on the surface of mines.

Finally, some suggestions are made as to means of reducing the numbers of these common injuries.

I am indebted to the patients and, through the Welsh Regional Hospital Board, to the staff and management committee of the Miner's Rehabilitation Unit for their help and cooperation in this study, especially to Sister C. Thomas, and to Mr. A. O. Parker, consulting surgeon, who drew my attention to this problem.

Thanks are due to my colleagues, Drs. J. M. Davidson and S. Bridge Davis, of the Medical Inspectorate, Ministry of Fuel and Power, and to Dr. R. Doll of the Statistical Research Unit, Medical Research Council, for much help in the preparation of this paper. Dr. Graham Jones kindly supplied certain statistics relating to meniscus injuries in the steel industry.

I am grateful to the Ministry of Power for permission to publish.

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THE RESPONSIBILITIES OF THE MEDICAL PROFESSION IN THE USE OF *X* RAYS AND OTHER IONIZING RADIATION*

I. Introduction

1. The United Nations General Assembly, being aware of the problems in public health that are created by the developments of atomic energy, established a Scientific Committee on the Effects of Atomic Radiation. This Committee has considered that one of its most urgent tasks was to collect as much information as possible on the amount of radiation to which man is exposed today, and on the effects of this radiation. Since it has become evident that radiation due to diagnostic radiology and to radiotherapy constitutes a substantial proportion of the total radiation received by the human race, the Committee considers it desirable to draw attention to information that has been obtained on this subject.

2. Modern medicine has contributed to the control of many diseases and has substantially prolonged the span of human life. These results have depended in part on the use of radiation in the detection, diagnosis, and treatment of disease. There are, however, few examples of scientific progress that are not attended by some disadvantages, however slight. It is desirable therefore to review objectively the possible present or future consequences of increased irradiation of populations which result from these medical applications of radiation.

II. General Survey of the Irradiation of Human Beings

3. Man has always been exposed to some irradiation from natural sources. To this has now been added, as a result of modern discoveries and the applications of ionizing radiation and radioactivity, certain forms of artificial irradiation.

4. Natural irradiation is due to (1) cosmic radiation; (2) "background" gamma radiation from radioactive substances present locally in the earth, rock, or building materials, and from disintegration products of radon in air; (3) radiations emitted from natural radioelements such as potassium 40, radium, radon, and carbon 14, which are incorporated in the body.

5. The amount of this natural radiation varies with locality, but has been estimated as usually delivering between 70 and 170 mrems per year to the gonads. Of this total, the majority contributions are of about 45% from local gamma radiations, 30% from cosmic rays, and 20% from body potassium 40. These figures are based on reports sent by India, Sweden, the United Kingdom, and the United States of America.

6. Artificial irradiation is derived from (1) the contamination of the environment, the atmosphere, or water by radioactive waste from atomic industries or from users of radioelements; (2) the radioactive fall-out, at greater or lesser distances from the source, of radioactivity resulting from the explosion of nuclear devices; (3) the occupational exposure of certain groups of workers—medical practitioners, radiologists, dentists, nurses, atomic energy workers, uranium or thorium miners, and the industrial or scientific users of radiation generators or radioactive isotopes; (4) the medical use of *x* rays, other ionizing radiations and radioelements in the detection, diagnosis, investigation, and treatment of human diseases; (5) the use of certain devices which emit radiation, such as television receivers, watches with luminous dials, and the *x*-ray generators used for the purpose of fitting shoes.

7. The amount of artificial radiation must vary considerably in different countries and we have inadequate information on the overall significance of these factors. In certain countries where estimates have been made, it appears that the greatest gonad irridiation of the population is due to diagnostic radiological procedures, the amount from this source about equalling that from all natural sources in certain instances. The total present contribution from occupational exposure, from the products of atomic industries, from radiotherapy, and from the radiating devices mentioned above (paragraph 6, sub-paragraph 5) is likely to be very considerably smaller. That from radioactive fall-out to the gonads appears at present to be in the region of 1% of the natural gonad irradiation in most areas, according

* Submitted for publication in January, 1957, by the United Nations Scientific Committee on the Effects of Atomic Radiation.

to the reports sent by the United Kingdom and the United States of America.

8. Both the magnitude and the significance of these various sources are under review by the Committee. Since medical irradiation accounts for a substantial if not the major proportion of all artificial exposure, it is important that its magnitude should be known accurately for different countries and circumstances. The possibility of making such an assessment depends upon the help of the medical profession, and particularly on the adequacy and availability of records kept by doctors, dentists, and organizations responsible for the use of ionizing radiation.

III. Radiation Hazards

9. The medical use of radiation is clearly of the utmost value in the prevention, diagnosis, investigation, and treatment of human disease, but the possible effects of this irradiation of individuals require examination.

10. Generally speaking, the irradiation of living beings may produce radiobiological effects either on the irradiated individual himself or, through him, on his descendants, the former being termed somatic and the latter genetic effects. Somatic effects vary according to the different organs or tissues affected, and range from slight and reversible disturbances such as cutaneous erythema to the induction of leukaemia or of other malignant diseases. The possible reversibility of the somatic effects of radiation received in small doses or at low dose encourages the belief that there are permissible doses of radiation which will not cause completely irreversible or significant somatic damage. The threshold for occasional somatic damage may, however, prove to be low. In the case of genetic effects on the other hand there may be no threshold. These effects increase with a frequency corresponding to the total amount of radiation received by the germinal tissues, and, in the great majority of cases, are adverse.

11. Many other factors complicate the interpretation of radiobiological effects. The differences between whole and partial body radiation, between a single exposure and continuous irradiation, or between the effects of different types of radiation are still imperfectly understood. Biological differences in the radiosensitivity of various tissues, or of the tissues of people of different age or sex, obviously influence the nature of radiation hazards. It is clear, however, that any radiation of gonads, and any substantial irradiation of other tissues, involves a chance of significant damage which requires assessment.

IV. General Recommendations Regarding the Medical and Occupational Irradiation of Human Beings

12. The radiological profession, through the International Commission on Radiological Protection (1954), has undertaken a valuable and responsible duty in defining maximum permissible limits of exposure for the main radiation hazards.

13. The establishment of these maximum permissible levels for those who are occupationally exposed to radiation depends on the view that there are doses which, in the light of our present knowledge, do not cause detectable somatic injury in the individual irradiated; and on the consideration that the number of individuals concerned is small enough for the genetic effects on the whole population to be negligible. For the gonads, or for irradiation of the whole body, the levels are such as to exclude doses greater than 0·3 rem in any week or 3·0 rem in any 13 weeks, or a sustained irradiation rate greater than 5 rem per year. These values imply that no total dose of over 50 rem will have been received by the gonads by the age of 30, or of over 200 rem by the whole body by the age of 60, in any occupationally exposed person (International Commission on Radiological Protection, 1954).

As regards irradiation of the whole population, it is considered prudent to limit the average dose to germinal tissues from artificial sources to the order of magnitude of that received from all natural sources.

14. In considering the extent to which the population is irradiated for medical purposes, it is essentially the genetic hazard which is involved although it seems possible that in certain circumstances somatic injury may occur occasionally after low doses of radiation. Otherwise, the relevant dose is that indicating the mean gonad irradiation among the population as a whole up to the end of the average reproductive period.

15. The extent of such genetic irradiation from diagnostic procedures has been found to be equal to at least 100% of all natural radiation in Sweden and the United States of America and that from the United Kingdom equalled at least 22% of this figure. Even before obtaining more exact values for these and other countries, it is clear that the exposure can be substantial in countries with extensive medical facilities, and that it is essential to consider any ways in which this exposure could be reduced without detriment to the existing or developing value of medical radiology.

16. The Committee is therefore anxious to obtain the help of radiologists in suggesting through appropriate governmental channels any methods by which this total exposure could be reduced and in

estimating the amount of reduction that might be expected from any such methods. In particular it would be valuable to know how much the radiation to the gonads could be reduced (*a*) by improved design or shielding of equipment; (*b*) by fuller training of any individuals using radiographic or fluoroscopic equipment; (*c*) by any local shielding of the gonads that is practicable, especially during abdominal or pelvic examination; (*d*) by the use of techniques involving radiography rather than fluoroscopy when full information can be obtained by this means; (*e*) by improvement of administrative arrangements designed to obviate unnecessary repetition of identical examinations of the same subject; (*f*) by a general study of certain medical conditions such as that of peptic ulcers, to identify the circumstances in which the establishment of a radiological diagnosis has or has not a definite influence upon the treatment or prognosis given.

Summary

1. The Scientific Committee on the Effects of Atomic Radiation established by the United Nations General Assembly accepts the view that the irradiation of human beings, and especially of their germinal tissue, has certain undesirable effects.

2. Information received so far indicates that, in certain countries (Sweden, United Kingdom, United States of America), by far the most important artificial source of such irradiation is the use of radiological methods of diagnosis and that this may be equal in importance to radiation from all natural sources. It is possible that such radiation may be having a significant genetic effect on the population as a whole.

3. The Committee is fully aware of the importance and value of the medical use of radiations but wishes to draw the attention of the medical profession to these facts and to the need for a more accurate estimate of the amount of exposure from this source. The help of the medical profession would be most valuable to make it possible to obtain fuller information on this subject.

4. The Committee would be particularly grateful for information through appropriate governmental channels on ways in which the medical irradiation of the population can be reduced without diminishing the true value of radiology in diagnosis or treatment.

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MISCELLANEA

Occupational Mortality in Scotland

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(RECEIVED FOR PUBLICATION FEBRUARY 11, 1957)

The Registrar-General for Scotland has recently published (Registrar-General for Scotland, 1956) his analysis of the deaths in Scotland from 1949 to 1953 in relation to the occupational distribution found in that country at the 1951 Census. This note focuses attention on two subjects in his Report, coronary heart disease and cancer of the respiratory system.

As the population concerned is relatively small (1,795,273 males aged 15 and over), occupations have been grouped in the Report in order to provide adequate numbers of deaths from the specific causes given. Some of these groupings bring together men working in very different conditions (*e.g.*, " other water transport workers " includes firemen, greasers, pursers, stewards, bargemen, lock-keepers), and such groups have been excluded from consideration here.

The Report gives standardized mortality ratios (S.M.R.) for males aged 15 and over and aged 15 to 64 years for the following causes of death:—All tuberculosis; malignant neoplasms—total, and of the respiratory system; vascular lesions affecting the central nervous system; coronary heart disease; myocardial degeneration, etc.; bronchitis and pneumonia; accidental death. Only the S.M.R. at ages 15 to 64 years is considered here as the reliability of information both about a man's last job and his cause of death probably diminishes after the age of 65. Unfortunately, the actual numbers of deaths from particular causes are not given for this age range, only the total number at ages 15 and over. The numbers of deaths in the required range have, however, been estimated and, in general, only occupations with S.M.R.s based on 50 or more deaths are discussed in this note. Where the number of deaths is possibly a little less than 50, the S.M.R. is printed in italics.

Definitions

Classification of Occupations.—The classification used is the official publication of H.M. Stationery Office (General Register office, 1951). The code numbers used are those given in that publication.

Standardized Mortality Ratio.—This is the ratio of actual to " expected " deaths, expressed as a percentage. The expected deaths are calculated by multiplying the age-specific death rates for all males by the number of men in the corresponding age groups in the particular occupation. Thus the ratio for all males is 100. For example, an S.M.R. of 143 for coronary disease in clerks means that clerks have a death rate from coronary disease 43% higher than the rate for all males, when the effect of any difference in age structure between clerks and all males has been taken into account.

Registration of Death.—When a death is registered the informant is asked to give the last occupation of the deceased. This occupation may not, for various reasons, have been the job in which a man spent most of his working life, or the job recorded by him at the Census. Such differences are, naturally, more likely with men over 65 years of age.

Coronary Heart Disease

Occupations with an S.M.R. of 130 and above can be divided into two groups, those with no other S.M.R. (for the causes listed) of 130 and above, and those with other high S.M.R.s. Tables 1 and 2 list occupations according to these criteria.

TABLE 1

CORONARY DISEASE S.M.R. 130 AND ABOVE AND NO OTHER CAUSE 130 AND ABOVE

Occupational Code Number	Occupation	Coronary Disease S.M.R.	Social Class	Physical Activity
650, 651, 663	Bus, tramway, and garage managers	*147*	I & II	Light
764-765	Judges, solicitors	*146*	I	Light
890-895	Clerks (typists), etc.	143	III	Light
585	Plasterers	*141*	III	Intermediate
620-629	Managers in industrial undertakings (other than managers of office departments)	136	II	Light
715	Commercial travellers	133	III	Light
755	Insurance agents	130	III	Light

The classification of the occupation as " heavy ", " light ", " intermediate ", or " doubtful " is derived from a paper on mortality in relation to physical activity at work (Morris and Heady, 1953). All occupations in social classes I and II, except farmers, are regarded as " light ".

Before discussing these tables, the obverse of the coin should be shown. Table 3, therefore, gives occupations with S.M.R.s of 70 or below.

This kind of evidence, based on crude occupational groupings and relatively small numbers of deaths, is unlikely to confirm or refute any particular hypothesis. However, it does give an opportunity to speculate and to look for clues that may be followed when the more detailed information for England and Wales becomes available.

TABLE 2

CORONARY DISEASE S.M.R. 130 AND ABOVE AND OTHER (SPECIFIED) CAUSES 130 AND ABOVE

Occupational Code Number	Occupation	S.M.R.			Social Class	Physical Activity
		Coronary Disease	Other Causes			
750-754, 756-759	Company directors, stockbrokers, etc.	196	Vascular lesions of the C.N.S.	187	I & II	Light
766-769	Physicians and surgeons	158	Vascular lesions of the C.N.S.	*183*	I	Light
			Accidental death	*139*		
610-611	Civil Service, administrative and executive classes	154	Vascular lesions of the C.N.S.	*187*	I & II	Light
830-831	Police	147	Vascular lesions of the C.N.S.	*187*	III	Light
710-714, 720-729	Proprietors and managers in commerce, finance, and insurance	141	Vascular lesions of the C.N.S.	131	II	Light
380-389	Garment workers	143	Tuberculosis	*238*	III & IV	Light

TABLE 3

CORONARY DISEASE S.M.R. 70 OR BELOW

Occupational Code Number	Occupation	Coronary Disease S.M.R.	Social Class	Physical Activity
030	Foresters	*44*	III	Heavy
010, 011, 018 020	Farmers	49	II	Intermediate
019, 021, 029 050-059	Farm workers, etc.	55	IV & V	Heavy
	Workers in mines, quarries (not coal-mining)	62	III & IV	Heavy

Current hypotheses about the cause of coronary disease include three (Morris, 1956) to which these data may be related: that physical activity at work is protective; that excess fat in the diet is harmful; that nervous strain is harmful. One fact is known, namely, the excess mortality in social classes I and II. This was first shown in the occupational mortality figures for 1930-32 (Registrar-General, 1938) and is again clearly demonstrated in this Report. This fits all three hypotheses, since men in these classes have light occupations (except farmers whose S.M.R. is 49), their diet is probably richer than that of the other classes (Ministry of Agriculture, Fisheries, and Food, 1956), and they are often considered to be subject to more nervous strain. When all these factors are present, there may be other results in addition to increased coronary disease mortality. For instance, of the men in social class III occupations with high coronary disease S.M.R.s, 86% appear in Table 1 and 14% in Table 2; for social class I and II occupations, 27% are in Table 1 and 73% in Table 2. Thus a high death rate from coronary disease in class I and II occupations tends to be associated with a high death rate from vascular lesions of the central nervous system, while in class III (with the exception of policemen) there is no such association.

Physical Activity.—All occupations, except plasterers, in Tables 1 and 2 are " light "; in contrast, none in Table 3 are " light ". To go any further with this hypothesis, more detail about occupations and their death rates is necessary. The kind of analysis that was done on the occupational mortality data for England and Wales in 1930-32 (Morris, Heady, Raffle, Roberts, and Parks, 1953) must await publication of the full figures for England and Wales.

Diet.—The only occupations exposed to the occupational hazards of eating larger quantities of dairy fats than average are farmers and farm workers. But excessive fat may only be harmful to men in " light " occupations and an interesting point arises from the presence of garment workers in Table 2. This group has the highest S.M.R. for tuberculosis (238) and one can speculate on the possibility of an association between a light occupation with an excess of tuberculosis which convalescent patients may pursue, on a diet rich in milk and butter-fat, and a high death rate from coronary disease. Similar occupations give the following results:—

Occupational Code Number	Occupation	S.M.R. for	
		Tuberculosis	Coronary Disease
360-369	Boot and shoe makers	*152*	109
799	Draughtsmen	*138*	118

" Nervous Strain ".—The occurrence of both " strain " and a richer diet in the same occupations has already been mentioned. Occupations in social classes I and II which have S.M.R.s below 130 (Table 4) may throw some light on the connexion of these two factors with coronary mortality.

TABLE 4

OCCUPATIONS IN SOCIAL CLASSES I AND II WITH CORONARY DISEASE S.M.R. BELOW 130*

Occupational Code Number	Occupation	Coronary Disease S.M.R.
786-794	Professional engineers, surveyors, etc.	129
760-763	Ministers of religion	106
612-615	Local authority officials, managers of commercial and industrial office departments	100
780, 785	Teachers	90

*Farmers are not included as they are not " light " workers

Both teachers and ministers of religion had high coronary disease S.M.R.s in England and Wales in 1930-32 (Registrar-General, 1938). Both occupations still appear to have plenty of " strain ", but have they not fallen behind the other professions in standards of living since 1932?

Cancer of the Respiratory System

There are good reasons for looking closely at the occupational data on lung cancer. Hueper (1956) has

reviewed the epidemiology of lung cancer and he quotes the many industries where a specific risk of developing this disease has been found. Examples include nickel refining (in Clydach, South Wales, and Norway), chromate production, the production of coal gas, the manufacture of asbestos, and of arsenical sheep dip. In addition, however, suggestions have been made that dangers exist in other industries. Wynder and Graham (1951) suggested that "hot metal" workers and painters may be exposed to increased risk. A later study in the United States (Breslow, Hoaglin, Rasmussen, and Abrams, 1954) also found an association between exposure to metallic particles and fumes and lung cancer. In the United Kingdom, however, Doll (1953) found no such association.

Table 5 lists occupations with respiratory cancer S.M.R.s of 130 and above.

TABLE 5

MALIGNANT NEOPLASM OF RESPIRATORY SYSTEM S.M.R. 130 AND ABOVE

Occupational Code Number	Occupation	S.M.R.
160-164	Platers, riveters, and shipwrights	183
231-249	Electrical apparatus makers and fitters and electricians	170
131, 132	Moulders	162
589	Masons and stone cutters	*162*
134-138	Foundry labourers, etc.	*161*
681	Dock labourers	157
912	Crane drivers	*150*
600-609	Painters and decorators	132

Few occupations had an S.M.R. below 70; men in open-air occupations made up 80% of these (Table 6). The majority of such men are probably working in rural areas.

TABLE 6

MALIGNANT NEOPLASM OF RESPIRATORY SYSTEM S.M.R. 70 OR LESS

Occupational Code Number	Occupation	S.M.R.
019, 021, 029	Farm workers, etc.	*25*
010, 011, 018, 020	Farmers, etc.	27
110-119	Foremen and overlookers in metal manufacture and engineering	*54*
013-015	Market and other gardeners	*56*
620-629	Managers in industrial undertakings (other than managers of office departments)	69

Of the eight occupational groups with high S.M.R.s, five seem to fit Wynder and Graham's suggestions: painters and decorators and the four groups associated with "hot metal" working—platers and riveters, moulders, foundry labourers, and some crane drivers (not all crane drivers, of course, work in metal industries). It is interesting that one of the specific occupations suspected in the United States recently (Breslow and others, 1954) was "electric bridge crane operators—metal industry".

In 1930-32 (Registrar-General, 1938) the occupation with the highest S.M.R. for lung cancer was "skilled workers in gas works" with 367. Fourth and fifth highest respectively were "metal moulders and casters" 193, and "iron foundry furnacemen and labourers" 188. Gas workers have since been shown to suffer a real excess mortality (Doll, 1952), so it may well be that "hot metal" workers deserve a comprehensive investigation.

Two of the occupational groups in Tables 5 and 6 need special care in the interpretation of their S.M.R.s. These are platers, riveters, and shipwrights who have a high S.M.R. for every cause, and foremen and overlookers in metal manufacturing with low ratios for every cause. In such cases, there may have been errors in the population. For example, when foremen die, their job may not be given in sufficient detail and the death may be attributed to other occupational groups in metal manufacture. Thus foremen would appear to have low ratios while those in the other groups may be slightly inflated. (The numbers of foremen are small in relation to other workers, so errors are not likely to raise other ratios significantly.) This kind of error does not seem so likely in the case of platers, riveters, and shipwrights, and their high S.M.R.s may reflect bad conditions of work in shipyards, including such adverse effects as returning to work too soon after illness.

Occupational Selection

One further point of general interest in the study of occupational death rates might be mentioned. This is the possibility that high rates for a particular disease in any occupation may be due to men with the disease selecting a suitable occupation, or of men with generally poor physique selecting certain light occupations. This factor is clearly shown by the S.M.R.s for "not gainfully employed" males between the ages of 15 and 64. This group has low ratios for all causes except tuberculosis (220), myocardial degeneration, etc. (200), and bronchitis and pneumonia (175). It is not likely that because men are unemployed they die from these particular diseases, but that they are unemployed because they suffer from chronic conditions such as tuberculosis or bronchitis. The type of recruit entering any particular industry must, therefore, always be taken into account.

There are many other observations to be made on this material from Scotland and many facts of interest to all concerned with occupational health and disease.

I am grateful to colleagues in the Social Medicine Research Unit for their advice.

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Work, Conflict, and Community

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(RECEIVED FOR PUBLICATION FEBRUARY 11, 1957)

Since 1945, the number and scope of industrial studies undertaken in Great Britain have increased considerably. For the most part, they have been directed at such issues as productivity, absences from work, labour turnover, strikes, and a variety of factors thought to be connected with them. An important minority of such investigations have, however, been addressed to the actual ways in which work is organized, authority exercised, information communicated, and social relationships maintained. From these, there has begun to emerge, both in this country and elsewhere, an interest in the nature of the relationships which exist between particular industrial undertakings and the local communities in which they are set (Warner, Lloyd, and Low, 1947; Walker, 1950; Simey, 1954; Banks, 1956). This interest is readily apparent in a recent report by members of Leeds University* of a study which they had made of a mining community in Yorkshire. So far this particular development in social inquiry has not had much impact on medical research though clearly it is a promising one for industrial and social medicine.

At the time of the study, the community concerned had a population of some 14,000. Coal had been won there since 1868, and although one of the local collieries was closed in 1935, the great majority of the men were still employed at collieries in the town or nearby. There were comparatively few other kinds of jobs available in the area for men, and few of any kind for women. Most of the inhabitants came from families in which the menfolk of two, and often three, generations had worked in the pits. Thus for almost a century the fortunes of the local community had been bound up with the history of the local collieries, and through them, with the history of coal-mining in Britain. Despite the changes since nationalization of the coal-mines (changes which have often seemed less important to men actually working in the pits than to outsiders) the miners' past sufferings and their struggles against the coal-owners were still a very real part of everyday life. When changes introduced by the National Coal Board for the development of the industry generally, or even quite specifically for the benefit of the miners locally, come to be applied in the pits, far from being improvements, they may turn out to be, or may be construed as being, disadvantageous; they may even appear to be attacks on the miners themselves, their standard of living, and their hard-won rights.

Disputes about wages are endemic in the Yorkshire collieries, and hardly a day goes by without a strike in one of them. Since miners are wage-earners and their wage is the sole enduring economic link between them and their employers, the National Coal Board in London, most of the conflicts between miners and management take the form of wage disputes. In view of the remarkably changeable character of the working conditions in collieries, piece-rates and a complicated system of payments to cover any particular difficulties encountered hardly seem the most suitable methods of payment for faceworkers. Indeed, it is sometimes difficult to avoid the suspicion that these methods of payment and the organization of work in collieries are expressly designed to provoke conflict. These problems are, however, by no means confined to Yorkshire or even to Great Britain; disputes leading to strikes are more common in mining than in most other trades throughout the world (Kerr and Siegel, 1954).

The most thorough-going and forceful part of the Leeds inquiry deals with the organization of work throughout the colliery. Until now, the most detailed social analysis of a colliery has been that of Trist and Bamforth (1951), which dealt mainly with the operations carried out in winning coal by the " long-wall " method. The Leeds team show that there are other important elements to be taken into account in studying the social organization of the pit. The work of maintaining and extending roadways underground, of transporting coal to the shaft and miners to and from the face, the division of the underground workers into highly paid faceworkers and quite poorly paid day-wage workers, together with the allocation of some of the " plum " jobs to allow for the dual responsibilities of trade union branch officials, and the previous experiences of miners on jobs other than their present ones, are shown to be powerful factors affecting the miners' reactions to the tasks immediately to hand, and their behaviour in situations at any given moment.

The faceworkers, who earned high wages by a kind of collective piece-work, displayed the greatest degree of cohesion against management. Men working on the transport system and other men on day-wages underground usually received no more than the minimum rate for this kind of work and earned perhaps only half as much as faceworkers and other contract workers. Their work was comparatively monotonous, its pace set by the machinery they tended, they had little control over it, and since, unlike the jobs at the face, their jobs were not interdependent, such workers did not develop permanent social groupings among themselves to anything like the same extent as the faceworkers. In this they resembled semi-skilled workers employed on assembly lines under broadly comparable conditions (Walker and Guest, 1952).

The main chance of occupational advancement for the day-wage workers was to become a faceworker. For the faceworkers themselves the main opportunity lay in getting an equally well-paid or even better-paid

* Coal is Our Life. By N. Dennis, F. Henriques, and C. Slaughter. (Pp. 250. 25s.) London: Eyre & Spottiswoode Ltd., 1956.

contract job on "back-ripping" or other development and repair work which was much less tightly scheduled. In practice the union branch officials had a lien on such jobs, so that their allocation was greatly affected by the conflicts inherent in the position of these officials. Such men could not simultaneously work at the face and represent their fellow workers in meetings with management, which were frequent, or carry out other essential union activities. Management, for its part, was usually willing to allot these less tightly scheduled jobs to union officials, who, in any case, were usually drawn from the ranks of the more experienced miners, in order to avoid any charges of discriminating against them on account of their union activities. At the same time, the frequent meetings between branch officials and managers, and the advantages which the former appeared to enjoy in obtaining relatively "soft" well-paid jobs were a constant source of friction with the men they represented, a conflict by no means peculiar to mining.

The theme of "industrial conflict", of conflict between workers and management, between workers and their unions, and between different sections of workers, which runs through the whole of this study has increasingly come to the forefront in industrial inquiries and indeed supplies the title for an American symposium on industrial relations (Kornhauser, Dubin, and Ross, 1954). In a sense, conflict is also one of the major issues underlying a further report on research at the Glacier Metal Company.* Observing that "the industrial scene continues to be disturbed by recurring difficulties in settling wages in the absence of a defined wage and salary scale", Dr. Jaques outlines methods which "might be considered a possible route towards a systematic pattern of financial reward in relation to the level of work done". In a complex situation involving many conflicts of interest, the discovery of one stable set of components might abate, or even remove, some of the conflicts. It is commonly thought that there is no real agreement between different sections of workers and management about "the rate for the job", or, more specifically, the appropriate rate for work done at a particular level. However, in the course of his inquiries, which are a continuation of studies already reported elsewhere† (Jaques, 1951), Dr. Jaques found that there did appear to be quite general agreement about "the rate for the job", provided that a distinction was made between the amount of work done in the course of a job and the level of work it represented.

To assess this level, it was necessary to discriminate between the prescribed and the discretionary content of the jobs being studied, and though there were many difficulties in the way, these were by no means insuperable. For the purpose of that analysis, the results of a job were taken as wholly prescribed, but the methods by which they were obtained appeared only prescribed in part. To some extent, there was always an element of discretion or judgment exercised in the use of particular methods, unless the job was absolutely automatic. This discretionary component of the job constituted the basis for making comparisons between jobs which, on the face of it, appeared completely different, since it contained an element which was unquestionably measurable, namely time. The maximum time span or period of time during which discretion was exercised before the work done came up for review, directly or indirectly, by a superior was found to be related to the wage or salary received, irrespective of the kind of work done or the title by which the occupation was known. Moreover, people who had about the same "maximum time span of discretion" tended to have similar views on what was a reasonable reward for their work.

Initially, the analysis was applied to the managerial and white-collar jobs in the firm, but it then appeared that it could be extended to manual work. The ensuing study of manual jobs gave rise to a new conception: that the level of work was related to the amount of the product which had to be scrapped as a result of failure to exercise "discretion"; thus discretion was related to the avoidance of damage. In this way it appeared possible to relate wage levels to the avoidance of damage in the course of production; the greater the potential damage that a worker might cause, the higher his level of work, and the higher his wage level. This in turn seemed to be related to the current rate of interest on loans. If the current rate of interest was, say 5%, an employee's wage or salary over the period during which he exercised discretionary control was roughly 5% of the value of the resources he controlled during that period.

Such procedures represent a major innovation in the study of work and wage structures. If the principles underlying them are at all applicable in industry at large, their impact could be very great indeed. It is therefore worth considering briefly what their probable limits are. One rough but ready test of this is the ease with which the main hypotheses can be reduced to absurdity. In the present instance, unfortunately, it can be done quite readily. If a worker's wage is, in effect, to be related to the amount of damage he avoids doing, it seems to follow that the less he does, the less risk he runs of producing scrap. The very best thing he can do is to stay away from work entirely because he then avoids the risk of causing damage altogether. Perhaps this is why shareholders are entitled to receive dividends. Actually manual workers and routine clerks, whether on piece rates or time rates are compelled to attend their place of work and to maintain a certain minimum level of production. In Dr. Jaques's notation this minimum constitutes an important part of the prescribed content of the job, and managements do indeed try to set the amount of work to be done. These attempts, however, often meet with considerable opposition. Disputes about production and the speed of working, especially in terms of wages, are the very stuff of industrial negotiations. Moreover, even when agreement is reached between unions and management on minimum levels of production often there is still considerable scope for controlling the pace of work and production itself on the shop floor, especially when

* Measurement of Responsibility: a Study of Work, Payment, and Individual Capacity. By E. Jaques. (Pp. 140. 15s.) London: Tavistock Publications, 1956.

† Reviewed in this journal (1951, 8, 306.)

piece rates and production bonuses are involved (Moore, 1951; Caplow, 1954; Lupton, 1956).

It seems then that though this kind of analysis may have some application in the grading of white-collar and managerial jobs, and perhaps in manual jobs where the workers are not well organized, the possibilities of extending it to manual jobs in general, especially where the workers concerned are well organized, are extremely limited. Moreover, it seems unlikely that agreements on the relative worth of jobs will extend over the entire range of occupations in an undertaking. White-collar and managerial workers may agree among themselves about the pay which jobs within their own range merit. They may even agree about the payment of manual jobs compared with their own, especially if the former happen to be paid less. It is less likely that manual workers will agree on the pay attaching to white-collar and managerial jobs, although regional variations and local factors may be important here. Possibly such agreement might be reached in the west London suburbs where most of the Glacier employees presumably live, but in other parts of London and elsewhere many manual workers vigorously dispute the pay and prestige attaching to white-collar and managerial jobs, as both the study of coal-miners discussed earlier and the work of the Institute of Community Studies attest (Young and Willmott, 1956). Finally, agreements reached in one sector of social life do not necessarily hold in another. Men may agree at the place of work where they attend to earn money that skill, extra effort, and responsibility should be rewarded. Outside the place of work, where earnings are spent, visible differences in wealth and standards of living may command something less than assent. Though it is legitimate, and indeed necessary, to isolate phenomena as far as possible for closer study, eventually they have to be restored to their original setting. Valuable results have been obtained by studying the social processes which operate in factories, mines, shops, and offices, but life is not confined to them. These processes are modified by the interchanges which take place with processes operating in the local community and outside the place of work. Sooner or later, both sets of processes have to be taken into account.

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A Discussion of Technique and an Analysis of Errors in Taking Industrial Histories in Coal-miners

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(RECEIVED FOR PUBLICATION, JANUARY, 1957)

The following description of the technique of industrial history taking employed by the Medical Research Council's Pneumoconiosis Research Unit in their chest radiography surveys at various collieries in this country (Cochrane, Davies, Chapman, and Rae, 1956) may be of some practical interest.

The technique we employ is simply to ask each man to give a chronological account of his occupations and places of employment since leaving school, and the information is tabulated on our industrial history form which has a series of sub-divisions into: (i) surface and underground occupations; (ii) various types of dust exposure—coal, stone, mixed, and minimal; (iii) the actual occupations. As our dust measurements have only been made at the coal face during the coal-getting shift, the occupations included under this heading are specially grouped. Other sections of the industrial history form are used for (i) any other information which has been collected at a particular survey, such as anthropometric of social data, (ii) the industrial history in the periods between surveys.

Practical complications arise during the actual history taking as a miner's working life is commonly elaborate and he often finds it difficult to remember every detail of his career in the correct sequence, especially any periods of unemployment, but we have enjoyed the cooperation and forbearance of the vast majority of the miners we have interviewed.

As it is by means of his industrial history that a man's dust exposure may be estimated and related to the radiological findings, it is apparent that the same care and meticulous technique should be applied to the taking of an industrial history as to the reading of the radiograph, but the possible errors in the former were not appreciated so early as were those of radiological diagnosis, and we have found no reference to their magnitude in the literature. Over 20 people have taken industrial histories during our surveys and we have investigated in three ways the observer error involved:

(1) Retaking industrial histories of the same men after a period of two and a half years; complete industrial histories were taken of the " pure face workers " at a South Wales colliery on two separate occasions in 1947 and 1949, and the results are compared in Table I. The errors appear small and random, even though this

TABLE 1

DIFFERENCE IN STATED NUMBER OF MONTHS WORKING ON COAL FACE IN A GROUP OF INDUSTRIAL HISTORIES TAKEN AT A SOUTH WALES COLLIERY IN 1947 AND IN 1949

Collier's Lamp No.	Months on Coal Face up to 1947 from 1947 Industrial History	Months on Coal Face up to 1947 from 1949 Industrial History	Difference
279	48	48	0
475	36	30	— 6
581	57	48	— 9
588	54	54	0
25	72	66	— 6
488	42	42	0
624	54	66	+12
24	78	78	0
209	84	78	— 6
359	84	78	— 6
147	9	18	+ 9
513	36	27	— 9
45	18	24	+ 6
712	22	18	— 4
670	29	36	+ 7
718	30	36	+ 6
739	30	39	+ 9
697	36	42	+ 6
263	85	78	— 7
473	84	84	0
685	66	84	+18
729	60	60	0
725	78	84	+ 6
447	90	90	0
36	84	84	0
38	90	90	0
Total 26	1,456	1,482	+26
Average	56	57	+ 1

comparison magnifies them. It should be stressed that there was no common member between the industrial history-taking team in 1947 and 1949, a different form was used in the later survey, and in the interim period our industrial history-taking technique had been elaborated.

(2) Comparisons between characteristics of industrial histories of groups of miners questioned by different observers at a single survey; this technique, previously used by Cochrane, Chapman, and Oldham (1951) to investigate observer error in medical history taking, is briefly as follows. If it can be shown that miners choose or are chosen by the industrial history takers in a random way (as by an analysis of the age distribution of those seen by each observer) then the differences in any characteristics of the groups seen by each observer are a measure of the systematic error involved in assessing these characteristics. At an English colliery, four observers took industrial histories from the miners, and the groups seen by each of the four were shown to have the same age distribution. Table 2 shows an analysis of the distribution of the number of years worked underground by the miners in these groups, and Table 3 a similar analysis by years worked on the coal face. Statistical analysis showed no evidence of bias amongst the observers.

(3) The histories taken and the colliery records of the men may be compared. Our investigations in this direction have been hampered by the lack of suitable colliery records, the only ones available consisting of weekly time-sheets covering comparatively short periods of time (not exceeding five years) and with the occupations

TABLE 2

DISTRIBUTION OF NUMBER OF YEARS WORKED UNDERGROUND BY MINERS AT AN ENGLISH COLLIERY AS RECORDED BY FOUR OBSERVERS

No. of Years Underground	Observer A		Observer B		Observer C		Observer D	
	No. of Men Seen	%	No. of Men Seen	%	No. of Men Seen	%	No. of Men Seen	%
<5	36	13·8	32	12·8	34	11·4	24	13·3
5–9	38	14·6	35	14·0	50	16·7	35	19·3
10–14	32	12·3	39	15·6	39	13·0	28	15·5
15–19	31	11·9	44	17·6	49	16·4	32	17·7
20–24	48	18·4	33	13·2	53	17·7	25	13·8
25–29	30	11·5	32	12·8	33	11·0	20	11·0
30–34	16	6·1	18	7·2	22	7·4	10	5·5
35–39	11	4·2	7	2·8	9	3·0	1	0·6
40+	19	7·3	10	4·0	10	3·3	6	3·3
Total	261		250		299		181	

TABLE 3

DISTRIBUTION OF NUMBER OF YEARS WORKED ON COAL FACE BY MINERS AT AN ENGLISH COLLIERY AS RECORDED BY FOUR OBSERVERS

No. of Years on Coal Face	Observer A		Observer B		Observer C		Observer D	
	No. of Men Seen	%	No. of Men Seen	%	No. of Men Seen	%	No. of Men Seen	%
<5	48	24·7	45	23·4	48	21·3	35	26·3
5–9	38	19·6	32	16·7	41	18·2	27	20·3
10–14	24	12·4	37	19·3	41	18·2	20	15·0
15–19	28	14·4	27	14·1	43	19·1	22	16·5
20–24	26	13·4	23	12·0	25	11·1	16	12·0
25–29	10	5·2	15	7·8	18	8·0	9	6·8
30–34	10	5·2	5	2·6	6	2·7	4	3·0
35–39	6	3·1	6	3·1	3	1·3	—	—
40+	4	2·1	2	1·0	—	—	—	—
Total	194		192		225		133	

sub-divided into "colliers" and "day-wage men" in contrast to our more detailed classification. Consequently we have applied this technique to a small sample of the histories taken between two of our surveys at a South Wales colliery. In the sample there were 20 colliers. All of these were confirmed from the colliery records as having been colliers during the period mentioned in the industrial history, and the day-wage men were confirmed as having been day-wage men. Five colliers underestimated their "time off" (one, one week, two, two weeks, one, three weeks, and one, four weeks), and four overestimated their "time off" (one, one week, one, two weeks, one, four weeks, and one, six weeks).

Undoubtedly some errors remain, but we have no experimental evidence to show by what techniques they could be reduced. Repeat assessments are too time-consuming to be applicable, and we can only suggest that industrial history-taking should be the task of the minimum possible number of observers with the maximum possible skill and knowledge of mining and miners.

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A New Kit for Sodium Nitrite-thiosulphate Therapy in the Treatment of Acute Cyanide Poisoning

N. LANGDON LLOYD

From the Ministry of Supply

When the sodium nitrite-thiosulphate treatment of acute cyanide p isoning was first adopted in this country, it was difficult to find appropriate equipment (Lloyd Potter, 1950). All-glass 50 ml. syringes were unobtainable and it was necessary to manage with the equipment available. This entailed an unavoidable delay in administration of the drugs. Sterilization of the glass components presented difficulty in remote out-stations, where there was the added risk of breakages in transit. Moreover, the condition of the contents of the sealed, sterilized tin was always uncertain.

These outfits have now been replaced in Ministry of Supply establishments by a cyanide emergency kit for medical officers' use, fitted throughout with the "ampin" method of injection. Each kit contains treatment for two persons, with full instructions on an enclosed sheet.

Contents

For each of two casualties the following is provided:—

Ampin 1 (red label) containing 15 ml. 3% sodium nitrite in sterile distilled water (the dose, 10 ml.).

Ampin 2 (green label) containing 55 ml. 50% sodium thiosulphate in sterile distilled water (the dose, 50 ml.). Five millilitres is allowed in each for tubing space.

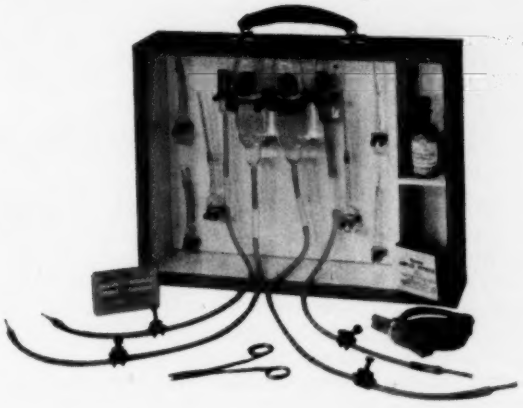
Nikethamide, 3 ml. for intravenous injection.

Lobeline hydrochloride, 0·003 g. in 1 ml. for intramuscular injection.

Nikethamide, 3 ml. for intracardiac injection.

Nikethamide and lobeline are supplied in " ampins ", which do not need syringes. In the photograph it is a little difficult to appreciate that the containers are " ampins " and not ampoules.

In a compartment are 12 capsules of amyl nitrite, one bottle of surgical spirit, two lengths of rubber tubing for venous tourniquet, one pair of Spencer Wells artery forceps. Sterilized cotton wool and adhesive dressings are added at the establishment and renewed as necessary.



Advantages

The kit is ready for instant use. Ampins 1 and 2 need not be removed from the case since each is provided with its own length of plastic tubing, drip chamber, and flow control, and both are sterile units in themselves.

Compared with the unpacking and assembly of syringes which must be filled repeatedly, and the technique of injecting at a fixed rate with a large syringe, much time and trouble are saved.

Replacements

The " ampins " of sodium thiosulphate are replaced once a year, the other " ampins " every third year.

The arrangement is that in any establishment carrying a cyanide hazard, one of these kits is kept at hand in the medical department and one at each site of a cyanide hazard. Following emergency treatment, the spare kit can, if necessary, be sent to hospital with the casualty.

The kit is neatly assembled, clipped into a stout wooden box with a perspex front, standing 15½ in. wide, 12 in. high, 4 in. deep. It has been made to our requirements by Messrs. Cuxson Gerrard & Co., Ltd., in consultation with Messrs. Ampins, Ltd., to both of whom we are much indebted for helpful advice.

This kit does not replace the cyanide poisoning first-aid requirements for factories (Factory Form 385—Cyanide Poisoning, June 1953) under which amyl nitrite capsules and draughts of cyanide antidote must be held independently at the site of hazard.

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BOOK REVIEWS

Minimal Pulmonary Tuberculosis Found by Mass Radiography (Fluorography). Royal College of Surgeons Prophit Tuberculosis Survey. A report to the Prophit Committee by V. H. Springett and including results of work done by A. J. Eley. (Pp. xiv + 242; 16 line drawings, 65 half-tones on 21 plates. 42*s*.) London: H. K. Lewis. 1956.

This study by the Prophit scholar is a comprehensive, carefully analysed and clearly tabulated follow-up investigation of 1,200 cases of " minimal tuberculosis ", found by two London mass radiography units in persons aged 15-44 years during the period 1946 to 1948.

Of the wealth of material and conclusions, only some can be mentioned here. The excellent summaries to each chapter will be a great help to readers but should not distract them from perusing the entire book and particularly the tables, which are most interesting.

Dr. Springett's report will distress that dwindling but vociferous section of doctors who still believe that early pulmonary tuberculosis causes well-marked clinical symptoms, or physical signs, which can be detected by inspection, percussion, and auscultation. Ninety-nine per cent. of his patients stated at first examination that they were in normal health; physical signs were found in 20% only. The report therefore confirms that timely recognition of minimal tuberculosis is a matter of radiology.

On the other hand, the various types of low density shadows do not permit prognostic conclusions to be drawn with any degree of accuracy or a clear-cut differentiation to be made into those lesions which are likely to remain or become quiescent and those which will progress.

The instability of minimal lesions, particularly in young persons, is clearly shown. Forty-four per cent. of the 1,200 patients showed either radiological progression or produced tubercle bacilli (or both) during the five years' follow-up and the development of larger lesions was, in many cases, associated with lack of regular supervision. Dr. Springett therefore stresses the need for frequent and regular supervision, particularly during the first 18 months after diagnosis. Indeed, his thesis, that " no person with a lesion that is not entirely calcified can properly be discharged from supervision as the result of a single examination ", seems to be the most important conclusion of the study and could be usefully attached to the viewing screens of chest physicians and doctors in charge of mass radiography.

From the point of view of prevention, it is significant that in not less than 30% of the examined group tubercle bacilli were found on at least one occasion. This high proportion of positive results in minimal lesions was due mostly to the systematic use of laryngeal swab cultures. In clinics and field investigations, there may still be a much wider scope for the use of this technically easy method than is practised at present.

By an accident of timing, the survey refers to the period immediately before antibacterial drugs became generally available. The indications, as Dr. Springett points out, for active medical and surgical treatment have since become wider. The proportion of patients in whom an artificial pneumothorax would be attempted would today be smaller than in his series.

Not the least important part of the Prophit scholar's study is the discussion of the variability of assessment of radiographs by different readers or even by one reader on different occasions. It should be noted that the "observer error", as in Springett's series, also applies to full-sized films and not, as is sometimes erroneously believed, to miniature films only. One hopes that the formidable practical difficulties, which at present prevent the introduction of dual readings into routine mass radiography, will be overcome.

Dr. Springett does not mention that his investigations have already resulted in a long overdue change of classification of tuberculous lesions found by mass radiography. One hopes that the interpretation of the large amount of material of tuberculous lesions found by mass radiography and now more readily available from the returns of the Registrar-General will be entrusted to a not less competent, incisive, and cautious mind than his.

This book, a very worthy successor to the first Prophit report, must be of great interest, not only to chest physicians and epidemiologists, but also to doctors in industry, closely connected with workers who are under observation for minimal tuberculosis at clinics or who have returned, after treatment, to factories and offices.

The Prophit scholar could hardly have done better than to choose the work of Dr. Eley, one of the pioneers of mass radiography in this country, as the basis of his analysis.

E. POSNER

Health in Industry. A Contribution to the Study of Sickness Absence Experience in London Transport. (Pp. 177. 35*s*.) London: Butterworth. 1956.

The late Lord Horder, who was consulting Medical Adviser to London Transport, instituted a medical service which must be unique in the history of British industry. The present service partly arose from a demand by Lord Ashfield when he was Chairman of the old London Passenger Transport Board for more statistics about employees. Consequently an excellent system of collection, analysis, and interpretation of sickness absence statistics was started alongside the more formal medical

system so that the Board's doctors and others have been able to draw increasingly valuable information from the whole group as well as from the individual.

The statistics were realized to be woefully incomplete before the war, as they were in nearly every other industry or concern. When allegations of high incidences of disease, particularly peptic ulcer in drivers, were levelled at it, the Board had no answer to give and no conception as to whether they were right or not. In 1937 Professor Bradford Hill's report on sickness absence using the incomplete statistics available served perhaps best of all to highlight the need to have better statistics in a large and expanding modern concern with men of exceptional foresight at the top. With the development of the medical services after the war, and the Central Record of Staff Statistics which was formed, it was easy to include a system of sickness absence recording in this organization. No one would claim, however, that it was easy to institute such an efficient system as London Transport has today. Medical research workers are indebted to the designers of the scheme and many individual doctors and firms have received generous help and advice for designing schemes to suit their own purposes.

The scheme was designed with the close cooperation of the Staff administration officers, Mr. Spratling and Mr. Lloyd, with Dr. Norman, the Chief Medical Officer, and Dr. Raffle, who has been principally concerned in the detail of the scheme. A number of questions are clearly answered by the authors in the introductory part of the book. Perhaps the most burning question of all (despite published work by Raffle on this question) is whether the diagnoses given on the medical certificates are sufficiently accurate to be used. The authors confirm that, in their experience, they are sufficiently accurate. They state " we have no doubt that these medical certificates can safely be used as the basis of analysis of sickness absence into broad diagnostic groups ". The operative word here is " broad " and the 20 diagnostic groups they use are based on the " International Statistical Classification of Diseases, Injuries, and Causes of Death" (1948). The diagnoses are immediately transferable to other groupings for comparison with industries using different groups since they are on the International Classification. Using 20 groups they find that 80% of the diagnoses of the general practitioners coincide with diagnoses made by the medical officers on return to work.

Given that these statistics, including the diagnoses, are accurate enough to be of use, are they of sufficient value to justify the expense and trouble of collection ? The authors claim that they are already of considerable service to London Transport and others. They show clearly the influence of the working environment on health, they have been used in medical research, and they are detailed enough to show up more sickness in particular occupations and from particular diseases. By showing trends they are useful in preventive medicine; for example, a man who may not be found to be fully fit in some degree after a pre-employment medical examination, can perhaps be placed in a department free from the conditions likely to aggravate his disability. Similarly alternative suggestions for employment for those who have become unhealthy in the service of the Authority may be offered, saving a man from compulsory retirement.

With regard to expense the authors state that no extra clerks have been taken on peripherally and these statistics have been collected with little expense of money or effort. This can be confirmed by those (such as the reviewer) who have borrowed this scheme for their own purpose to use elsewhere. It can be said that the cost of the scheme is minimal in London Transport because the machinery for the collection of all types of statistics was already there, and the effort was expended by the authors in the planning stage. The method of collection at the periphery is virtually fool-proof as checks have shown.

In the preliminary chapters the rules are made, each decision being clearly explained. The reasons for taking, for example, the seven-day week against the five working days are that various groups work five, five and a half, or six days a week with varying rest days, and the best comparability can be obtained in this way. From the medical point of view it might also be argued that the seven-day against the five-day week is more realistic as illnesses do not end on Friday night and re-start on Monday morning. Following these rules, the statistical indices and the coding of diagnoses are the tables and graphs.

The tables show the following information in five-year age groups for each occupational group over three or more years:—

(*a*) The age-distribution of those exposed to risk; (*b*) for spells of one, two, or three days' duration, the number of days of sickness absence and the average annual duration, the number of spells beginning and the annual inception rate (spells); (*c*) for spells of four or more days the same information as in (*b*) together with the average length of spell; (*d*) statistics available in (*c*) for the 20 diagnostic groups. For central bus drivers additional information is available.

Administrative factors may affect sickness absence directly or indirectly, and these have not been forgotten. At the head of each occupational group the question of pre-employment medical examinations, medical certificates, resumption of duties after an absence, examination of eyesight, transfer to alternative employment, employment after age 65, hours of work, and payments during sickness are considered. Other concerns comparing their statistics with this large experience would be well advised to bear these administrative matters in mind.

The authors are to be congratulated on producing a book which will assist concerns to decide whether to keep statistics of sickness absence or not, how to undertake the collection and analysis of them if they decide to do so, and clear tables which make a base line of comparison for them. With its necessarily limited numbers and occupations this is only the fringe of the subject, but, here, for the first time, are published tables of sufficient numbers at risk for sufficiently long to enable research workers to use them with confidence; never before has such information been collected and analysed and such work is directly in the line of tradition of William Farr and his mortality data. There may also

be a crumb of comfort to our general practitioner colleagues in the London area who gave the basic information on which the study depends that their certificate writing has not been in vain; and which the " genius of English healers " has already " put to good account ".

J. P. W. HUGHES

The Functions of an Occupational Health Service in an Industrial Organization. (Pp. 70, 5*s*.) London: Association of Industrial Medical Officers. 1956.

Occupational health has so far made but slow progress in the academic sector. Most medical students learn little of the subject. Yet in field, factory, dockyard, mine, transport, and building construction the doctor also serves. All over the world this service is expanding. In Great Britain, the membership of the Association of Industrial Medical Officers has grown in 21 years from 35 to over 800. The Association has chosen the occasion of its 21st anniversary to issue a booklet of 70 pages setting out the functions and aims of an occupational health service. The booklet also describes the present extent of existing services and includes short descriptions of many of the societies and associations concerned with occupational health. Presumably the intention is to clarify, not to plan, and truly clarification is needed. The examples of existing services described, together with the appendix of associated organizations, provide a substantially complete picture. In addition there are useful tables of comparative costs of medical services and a reasonably full bibliography of occupational health publications. The main value of the booklet lies in these factual sections. All the threads in the tangle are here collected neatly. Many hours will be saved for any newly appointed industrial medical officer, social worker, industrial or medical administrator, who may wish to study or to make use of these services. The booklet would have been improved by a summary of the existing law on the subject (that relating to rehabilitation is given), and by at least a cursory glance at the more significant variations in practice in other countries.

On the matter of functions and aims the book is less satisfactory. In the first five pages some 20 or 30 functions are dealt with in a few lines each. Elsewhere, the functions of the National Coal Board's medical service are well summarized under seven heads, and those of the British Overseas Airways Corporation under six heads. Clearly it is possible to make do with a single sentence: " The function of an occupational health service is to foster the health and safety of people at work." Enlarging on this, there is hardly a function of medicine that cannot be found a place in appropriate circumstances—from psychiatry to sanitation, from vital statistics to Civil Defence, from cancer research to control of infectious disease. There could even be a place for paediatrics in factory creches. Where then is the value of a functional breakdown ? It should serve to explain the details of the service and to influence those who may doubt its value. Moreover, it should guide the inexperienced on priorities and warn them of pitfalls. Unfortunately, insufficient guidance is given here. A carefully considered and detailed statement on some 10 or a dozen of the main activities consistently associated with preserving health at work would have gone a long way to help those who seek guidance. It is of doubtful value to mention continued observation of young persons, advice on health and employment of older workers, advice on health of senior staff, encouragement of managers to advise staff to obtain medical advice, and accessibility to employees of medical advice as five separate functions (Page 4).

Only rehabilitation is dealt with at any length. The short chapter on this subject begins with the statement: " It has been estimated that there are three million people actually in need of rehabilitation; if this is correct, much remains to be done." Much indeed, but is it correct ? This is the type of assertion that the Association's members between them should have confirmed or refuted. One function which should have been discussed in detail is the vexed question of treatment and diagnostic investigation. At this point much is done that should not be done and much left undone that is necessary. Surely this needs a thorough airing.

Also it is not made clear who exactly is to be served by the occupational health service. Presumably " industrial organization " includes all the personnel in factories, mines, transport undertakings, and construction works, but who else ? Will the farmer, the nurseryman, and the orchardist be included ? Is an occupational health service to function for professional men, shop assistants, and local government personnel ? The objective should not fall short of all who work, even the housewife in some aspects of her labour.

Besides those already referred to, there are short chapters of two or three pages each on the introduction of an occupational health service, the constitution and functions of an occupational health team, and occupational health nursing services. The subject matter is not clearly demarcated, as indicated by the titles, and the principal characters of doctor and nurse wander somewhat indiscriminately across chapter boundaries. The fine intention of this booklet is not fully realized.

T. O. GARLAND

Health of Workers in Chromate Producing Industry. A study under the direction of W. M. Jafafer. Public Health Service Publication No. 192. (Pp. 131; 25 figures, 6 in colour, 41 tables.) Washington: Federal Security Agency. 1953.

The manufacture of chromates and bichromates used in electroplating, anodizing, and surface treatment of metals, tanning and colour making is a small but essential part of the heavy chemical industry. In the United States as in this country there are some six factories where manufacture takes place. On the user's side the skin hazards of chrome, ulceration, dermatitis, and perforation of the nasal septum, have been well known, particularly in the chrome-plating industry, and the chromate producers until recently were thought merely to share these hazards. But since Lehmann in 1932 described cases of lung cancer in chromate workers suspicion has been increasing that a real risk of this disease exists on the manufacturing side. It is noteworthy that no malignancy has been reported in any of the skin or nasal cases.

This invaluable study, conducted with typical American team work and thoroughness, presents the results of a clinical and environmental survey of six factories and 897 workers concerned with the manufacture of chromates and bichromates. The process consists of roasting finely ground chromite ore with soda ash or a soda ash-lime mixture to produce sodium chromate which is converted by acidification and crystallization into sodium bichromate.

Ten men, mean age 54·5 years and mean exposure to chromates 22·8 years, were found to have bronchogenic carcinoma. This represents a rate of 1,115 per 100,000, which is far higher than the rate found in a comparative group. A study of morbidity and mortality statistics for the industry showed that there were nearly 29 times as many deaths from respiratory cancer among chromate workers as the expected rate for all males in the United States. The rate for coloured males was higher than for white males. The excess incidence was confined to cancer of the respiratory tract. There was no excess for other sites.

Perforation of the nasal septum was found in 56·7% of chromate workers and again the incidence was higher among coloured men. The condition also developed more rapidly in this group. Fifty-four per cent. had skin ulcers or their scars, but only 2% had chrome dermatitis. There was no evidence of an undue incidence of dental caries though gingivitis and periodontitis were noticed with greater frequency among chromate workers.

The main feature of the environmental investigation was the discovery of an acid-soluble-water-insoluble chromium fraction, differing from the commoner trivalent or hexavalent compounds, which is present in the roast and residue from the leaching tanks. It is considered that this material, probably a calcium chromate-chromite complex, may be responsible for the occurrence of the disease. The practice in Germany and America is to use the residue to mix with the fresh ore, while in Britain it is discarded. This fact may explain Bidstrup's finding that there has been no unusual incidence of pulmonary carcinoma in the British chromate-producing industry.

The recommendations arising out of the survey include: (1) More complete enclosure of processes; (2) dust control features incorporated in design of new equipment; (3) local exhaust ventilation; (4) regular routine air analyses by competent persons; (5) good housekeeping to prevent spillage and accumulation of dust; (6) personal protection until air concentrations are reduced to a safe level; (7) routine radiograph every three months on men who have worked in the industry more than five years; (8) continuation of morbidity and mortality statistics; (9) continuation of biochemical and toxicological research on all chromium compounds.

R. MURRAY

Price's Textbook of the Practice of Medicine. Edited by Donald Hunter. (Pp. xiv + 1,774; 2 figures. 63*s*.) Oxford University Press (London: Cumberlege). 1956.

" Price's Textbook of Medicine " was always a mixed bag with some outstandingly good and some equally bad sections. Now, under the editorship of Dr. Donald Hunter, it retains this characteristic feature. Dr. Hunter claims that it is a " unique compilation of modern knowledge ". It is, indeed, encyclopaedic, including many rare diseases, but yet some common disorders appear to have slipped through the editor's mesh; for instance, I could find no reference in the index to cough syncope or senile osteoporosis. Unfortunately it also retains a fair sprinkling of Edwardian folk lore. In the treatment of cough in influenza it is stated that " dry cupping is often of service " and a nasal spray of chlorbutol and menthol in liquid paraffin is recommended without reference to its dangers. In the section on pulmonary tuberculosis two pages are devoted to collapse therapy, but only one to chemotherapy. The régimes described here are out of date and there is no clear statement on the necessity for using combinations of antibacterial drugs. Under portal cirrhosis there is no mention of portal systemic encephalopathy, and high-protein diets which may precipitate it are advised without warning. In the cardiac section there are four pages on electrocardiography but no illustrations; on the other hand, there is one illustration of an electroencephalogram in the neurological section. These random gleanings lead to a sense of wariness in accepting the reliability and balance of the book. Much of it is, however, excellent. Especially good are the introductory chapters on " Antibacterial Drugs " (but why more space to sulphonamides than to all the others put together ?), the " Anaemias " (by L. J. Witts) and " Diseases of the Kidney " (by Horace Evans and Clifford Wilson). What a pity it is that publishers do not issue offprints of the separate sections of these vast omnibuses so that we could pick the good ones without having to take the rubbish. To get 1,700 pages of text for 63*s*. is a good bargain, but it is rather like a mixed lot at an auction.

C. M. FLETCHER

Hutchison's Clinical Methods. By Donald Hunter and R. R. Bomford. (Pp. xv + 452; 25 plates, 95 figures. 18*s*. 6*d*.) London: Cassell. 1956.

Every British medical student and practitioner probably is or has been familiar with this remarkable book, which started its life in the year 1897 and after flourishing for 12 editions has now blossomed into a new and exciting thirteenth edition.

While we must deeply regret that Sir Robert Hutchison should have retired from the authorship of a work which he has for so long personally inspired, the present authors have thoughtfully altered the title to perpetuate not only his name in this connexion but also the fundamental philosophy with which Sir Robert Hutchison taught his students.

During its long years and many editions, *Clinical Methods* must have been reviewed many hundreds of times, and those who have read such reviews will be familiar with the words of praise lavished upon it. We know already from our own experience that it fits into the pocket (not quite so easily as before perhaps) and that it is a mine of useful information. Whether we are humble students anxiously feeling our way in the awesome fog of our first clinical studies or ambitious diagnosticians

seeking higher honours, this virile little volume packs into its 450 pages a systematic approach to medical practice without which our efforts would be sadly wasted.

This book was never intended as a textbook of medicine; true to the intentions of its original authors, it still adheres to the principle of stressing, above all things, the simple but careful steps that the clinician should take in his investigation of the human problem facing him. It is this approach to the patient that is all too easily forgotten in the midst of the increasingly complex diagnostic features of contemporary medicine, and it is in reminding us, throughout this book, to consider the real basis of clinical investigation, namely the details of history taking and the critical observation of the patient, that the authors perform their greatest service.

Such a guide is indispensable to the student, whose whole future depends on the quality of his first lessons by the bedside; it is also a gentle reminder to all practitioners not to ignore the obvious, nor to take unwarranted short cuts which seldom save time in the long run. To those who choose to pursue their medical studies for higher examinations or who are returning to clinical medicine, this book is excellent both for the quick revision which is required initially and for helping to retain a stable and simple outlook on medical practice, at a time when so much knowledge has to be acquired.

The text of this edition has been substantially revised and together with the progress already made in the last edition, the style is now contemporary and pleasantly readable. The detailed revision of the neurological section is excellent and the new illustrations here are a great improvement on those published previously. Equally satisfactory are the additions and alterations made to the chapter on the cardiovascular system, and the inclusion of greater detail in the interpretation of electrocardiograms should be of considerable value. Altogether the many improvements of this edition will give *Clinical Methods* new life and enhance its already well established reputation.

What has this book to offer the industrial medical officer ? Certainly this is primarily a clinician's guide, but to those medical officers whose duty it is to protect employees in the toxicological field or who are engaged in the routine inspection of employees as part of a positive health scheme, this book still carries its important message. Routine investigations and examinations are useless if the clinical methods employed become in any way sloppy and ill-defined. Here then is the industrial physician's conscience for scrupulous attention to those standards which he must set himself in his work amongst the potentially healthy members of society. In addition this book will provide him with most of the details of those techniques which he can well employ to advantage in the medical centre of his own particular industry.

P. R. BOYD

National Coal Board Medical Service: Research on Medical and Cognate Problems. Annual Report, 1955. (Pp. 19.) London: The National Coal Board.

This annual report for 1955, produced in a smaller format than that for 1954, appears in Cambridge blue—*e tenebris lux*, as the motto on the crest on the cover puts it. The contents, however, follow the main lines for the previous report and indicate the extent of the National Coal Board's research interests. These range from the accuracy of the description of jobs on death certificates to miners' rescue breathing apparatus; from field surveys of pneumoconiosis to the physiological and psychological effects of work in hot and humid atmospheres; and from dermatitis and epidermophytosis in coal-miners to lung and bladder cancer in coke-oven workers. The cognate problems include statistical studies of the factors affecting attendance, investigation of compensatable accidents, and the mobility of mining populations. Some of the research described in this report has been carried out by outside organizations receiving financial and other assistance from the National Coal Board. This is clearly indicated in the text and references to published work are given under the appropriate sections.

Certain important administrative changes are described. Two new committees concerned with human problems and technical research and development are expected to lead to an increased interest in research in these fields and the replacement of the Interdepartmental Research Committee by a new Advisory Committee on Human Problems under the Board member for science and the medical service should ensure coordination of these services. The report ends with a list of the members of the four advisory panels on epidemiology, industrial medicine, physiology, and psychology.

I. T. T. HIGGINS

Surgery of the Hand, 3rd ed. By Sterling Bunnell. (Pp. xv + 1079; 1047 figures, 9 colour plates. £7 7*s*.) London: Pitman Medical Publishing Co. 1956.

There is now widespread recognition that work in this field demands special study and application if worthwhile results are to be obtained. All over the world there has been a general improvement in hand surgery, especially over the last 10 years. Much of this progress is due to the dissemination of knowledge and experience gained by such pioneers as Dr. Sterling Bunnell. It is fitting, therefore, that we should welcome the third edition of Dr. Bunnell's book. First published in 1944, and appearing again in 1948, it now emerges in a larger and more complete form, though retaining its original format and style.

The book is a complete treatise on all aspects of disease and injury of the upper extremity, set against a background of the relevant anatomy, physiology and pathology. Every conceivable aspect of the subject receives thorough and complete consideration. Each procedure is adequately illustrated by case notes and diagrams or photographs; a complete bibliography is appended. Thus the book can be described, without irreverence, as the " Bible " of hand surgery. It is certain that anyone whose work involves the surgery of the upper limb cannot possibly be fully equipped if they have not read it.

All existing chapters have been completely revised and new sections have been added on the use of antibiotics in infective lesions, cross finger flaps for acute injuries, reconstruction of the damaged thumb, burns of the hand and arm, and a valuable section on the surgery of rheumatoid arthritis. In addition there are over 200 new illustrations.

Its size and price (7 guineas) may put it beyond the reach of many who would wish to possess it, but as a work of reference it could hardly be bettered, and it can be recommended without reserve.

HAROLD BOLTON

X-Rays: Their Origin, Dosage, and Practical Application, 7th ed. (Pp. vii + 331; 339 illustrations, 42*s*.) Bristol: John Wright. 1956.

This well-known textbook has been enlarged and now includes an excellent section on industrial radiography. It was originally published as an introduction to basic and radiation physics and *x*-ray apparatus construction; these chapters are comprehensive and with the aid of the diagrams and illustrations it is possible to obtain a good understanding of the fundamentals of *x*-ray physics, but the style of writing is " chatty " and often confusing.

The chapters on film technique and diagnosis are too general and require revision to bring them up to date; the serious reader would be well advised to refer to more experienced writers in these subjects. On page 200, it is stated " in medical radiography the density (photographic) is always very low—well below 1." Actually in chest radiography the density range is 0·3-1·5. The factors given in the exposure table (page 239) should be used with caution, especially the suggestion of using focal-film distance of 27 in. for bone radiography. Silver recovery by precipitation (page 211) is impracticable, and no mention is made of the modern method of electrolysis now in use in most large departments. On page 287 macroradiography is described under the heading of " microradiography ".

The tables at the end of the book are very useful but few radiologists would agree that chest screening (Table 18) may be carried out for a maximum of up to 60 minutes per three-week period. The inclusion of a bibliography would be helpful. The book can be highly recommended for the sections on basic and radiation physics, therapy, and *x* rays in industry. The chapters on the practical applications in the medical field require drastic revision. It is very well produced; the excellent illustrations contribute much to the value of this edition.

WILLIAM G. CLARKE

Books Received

(Review in a later issue is not precluded by notice here of books recently received.)

Expert Committee on Professional and Technical Education of Medical and Auxiliary Personnel: Third Report. World Health Organization Technical Report Series No. 109. (Pp. 19. 1*s*. 9*d*.) London: H.M. Stationery Office; Geneva: World Health Organization. 1956.

La Lutte Contre L'Incendie dans les Ateliers de Nettoyage à Sec Utilisant des Solvents Inflammables. By A. Vallaud and P. Salmon. (Pp. 96; 13 figures. Free.) Paris: Institut National de Securité, 9, Avenue Montaigne, Paris, VIIIè. 1956.

Lavorazioni che Espongono all'azione della Naftalina Omologhi—Naftoli e Naftilammine—Derivati Alogenati—Solfonati e Nebrati della Naftalina ed Omologhi. By Raffaela Guiliano and Mario Rafanelli. (Pp. 100 + index; illustrated. No price given.) Rome: Istituto Nazionale per l'Assicurazione contro gli Infortuni sul Lavoro. 1956.

Sicherheit und Gesundheit im Betrieb bei Transport und Verkehr. (*Verhandlungen der Deutschen gesellschaft für Arbeitsschutz*, Vol. 4.) Edited by E. Mager, W. Mutschler, and H. Steeg. (Pp. viii + 308; 104 figures. DM 25.-.) Darmstadt: Verlag Dr. Dietrich Steinkopff. 1956.

Manual of Industrial Medicine, 3rd ed. By Lemuel C. McGee. (Pp. x + 212. 24*s*.) London: Oxford University Press. 1956.

A Short History of Public Health. By C. Fraser Brockington. (Pp. vii + 235. 15*s*.) London: J. & A. Churchill. 1956.

The Treatment of Fractures, Vol. I. By Lorenz Böhler. (Pp. xxxii + 1072; 1527 figures. $24.50.) New York: Grune & Stratton. 1956.

Annual Report 1955-56. (Pp. 259. 5*s*.) London: British Standards Institution. 1956.

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Médecine du Travail, 2nd ed. Edited by Prof. C. Simonin in collaboration with various authors. (Pp. xii + 1406; 326 figures. Fr. frs. 6,800.-.) Paris: Librarie Maloine. 1956.

Urology and Industry. By Leonard Paul Wershub. (Pp. xviii + 151. 37*s*. 6*d*.) Oxford: Blackwell; Springfield, Illinois: Charles C. Thomas. 1956.

A Textbook of Psychiatry, 8th ed. By Sir David Henderson and the late R. D. Gillespie. (Pp. xii + 746. 35*s*.) London: Oxford University Press. 1956.

The Adaptation of Recreational Activities for Men in the Rehabilitation of Lower Limb Injuries. By Veida Barclay. (Pp. ix + 154; illustrated. 18*s*. 6*d*.) London: G. Bell & Sons. 1956.

First Aid in Coal Mines, 3rd ed. (Pp. 126; 21 figures. 2*s*. 3*d*.) London: The St. John Ambulance Association. 1956.

The Slough Industrial Health Service: Ninth Annual Report 1955-56. (Pp. 36. 2*s*.) Windsor: Oxley & Son. 1956.

The First Hundred Years: Cortivosteroid Therapy. (Pp. 92. Free.) Folkestone: Pfizer Ltd. 1956.

An Annotated Catalogue of the Mutant Genes of the House Mouse. By H. Grüneberg. Medical Research Council Memorandum No. 33. (Pp. 28. 2*s*. 6*d*.) London: H. M. Stationery Office. 1956.

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Air Pollution Handbook. Edited by Paul L. Magill, Francis R. Holden, and Charles Ackley; Editorial Consultant: Frederick G. Sawyer. (Pp. xi + 14 sections; illustrated. £5. 12*s*. 6*d*.) London: McGraw-Hill Book Co., Inc. 1956.

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Le Otopatie Da Rumore E Nozioni Di Audologia. By Vittorino Pescetti. (Pp. xii + 96; 17 figures. L. 1,200.-.) Rome: Edizioni E.N.P.I. 1956.

I Fondamenti Igienico-Fisiologici Della Illuminazione Razionale. By Antonio Tizzano. (Pp. x + 75; 53 figures. L. 1,200.-.) Rome: Edizioni E.N.P.I. 1956.

The Diseases of Occupations. Second enlarged and revised edition. By Donald Hunter. (Pp. xvii + 1100; 447 figures. £5. 5*s*.) London: The English Universities Press. 1957.

Principles of Epidemiology. By Ian Taylor and John Knowelden. (Pp. vii + 300; 26 figures. 30*s*.) London: J. & A. Churchill. 1957.

Reactions of Mines-rescue Personnel to Work in Hot Environments. By A. R. Lind, J. S. Weiner, R. F. Hellon, R. M. Jones, and D. C. Fraser. [Medical Research Council Memorandum.] (Pp. 68.) London: The National Coal Board. 1957.

Youth at Work: A study of adolescents in industry by an Appointed Factory Doctor. By M. E. M. Herford; Forewords by James M. Mackintosh and T. N. F. Wilson. (Pp. xvi + 154 + appendix. 18*s*. 6*d*.) London: Max Parrish. 1957.

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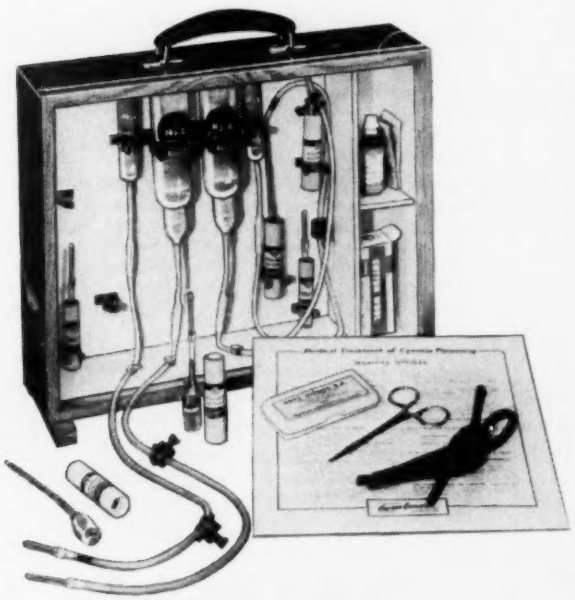

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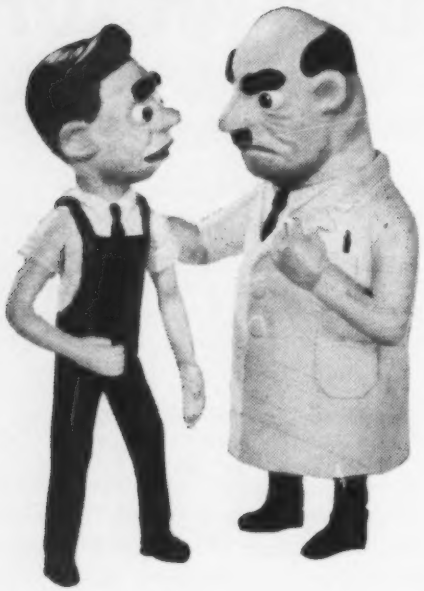

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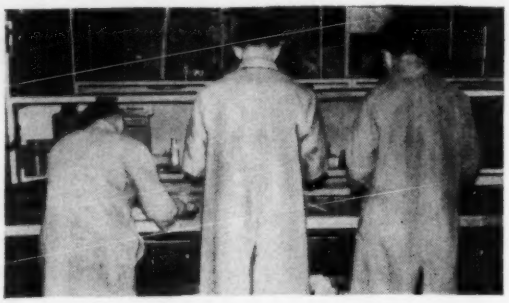

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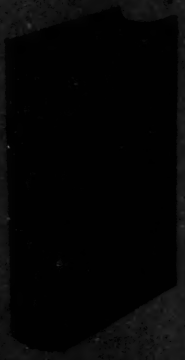

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[1] J. Amer. Chem. Soc. (1954) 76 6192.
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